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HUMAN RESOURCES DATA IN WEAPON SYSTEM DESIGN: AN INITIAL PLAN F--ETC(U)

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HUMAN RESOURCES DATA IN WEAPON SYSTEM DESIGN:
AN INITIAL PLAN FOR DEVELOPMENT OF A UNIFIED DATA BASE

By

Everett L. Thomas
Dorothy A. Newhouse
Clemson University
Clemson, South Carolina 29631

Robert J. Hankins
Lockheed-Georgia Company
Marietta, Georgia 30063

LOGISTICS AND TECHNICAL TRAINING DIVISION
Wright-Patterson Air Force Base, Ohio 45433

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NOTICE

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This technical report has been reviewed and is approved for publication.

ROSS L. MORGAN, Technical Director
Logistics and Technical Training Division

RONALD W. TERRY, Colonel, USAF
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The objective of this study is to establish an initial plan for development of a prototype unified data base (UDB) and of a data generating technology base (DGTB) of human resources information for use in weapon system design. The total study consisted of four tasks: (a) existing Air Force, Army, Navy, and other data systems which could support the UDB were reviewed, (b) the weapon system design and acquisition process was assessed in order to establish the concept of operation of a UDB, (c) user needs were identified in terms of the adequacy of the data systems investigated, and (d) an initial plan for the development of a prototype UDB was established based on the results of the first three tasks and on an industry survey. This report

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addresses the fourth task in which (a) a concept for the UDB was developed, (b) a concept for the operational use of the UDB was developed, and (c) an initial plan for the development of a prototype UDB/DGTB was established. This development plan addresses the initial structure, content, and process for a prototype UDB/DBTB which is evolving in a heuristic manner.

SUMMARY

BACKGROUND

Operational support costs represent a large percentage of the total life cycle cost of major weapon systems. The cost of human resources (manpower, personnel, training, etc.), is, in turn, one of the largest contributors to operational support costs. To a significant degree, operational support costs are determined by the operational/support concepts and performance/design characteristics of the weapon system hardware. Finally, most of the system concept and design decisions that significantly influence operational support costs are made during the early (conceptual and validation) program phases.

Department of Defense (DOD) policy has increasingly emphasized the need for developing ways to reduce operational support costs while maintaining mission effectiveness of weapon systems. For the past 10 years, the Logistics and Technical Training Division of the Air Force Human Resources Laboratory (AFHRL) has been developing basic technology addressing the relationships between human resources and complex weapon systems. This technology attempts to make it possible for manpower, personnel and training factors to have an influence on the hardware design/development process as well as to be influenced by it.

For many years, a large volume of historical data (human resource related) on operational weapon systems has been collected and processed. Historically, the primary use of these data has been to improve the operation and support (O&S) capabilities of existing systems, and the data systems have been tailored to satisfy these objectives.

In recent years, it has become evident that a unified data base (UDB) of human resources information is needed to support the weapon system acquisition process. The primary objective of this study was to establish an initial plan for development of a centrally located computerized on-line UDB of human resource related information for utilization in the weapon system acquisition process to influence hardware concepts and design.

The study consisted of four major tasks. The first was to identify data and data systems that would be useful in the weapon system

design process. The second was to define the system design process and to determine the extent to which human resources data (HRD) are used in early system design. The third was to assess the availability and adequacy of existing HRD for use in system design, and to identify requirements for improving those data. The fourth (which this report addresses) was to establish an initial plan for future development of a prototype UDB.

PROBLEM

There is a need for a UDB that will more effectively utilize historical data and provide a systematic, consistent way to develop and record HRD for an evolving new weapon system. There is also a need for a data generating technology base (DGTB) of technologies that provide generic and parametric HRD that will support weapon system designers in a timely manner such that a significant reduction in O&S costs can be made by early trade-off analyses which address human resources and logistics factors. HRD is fundamentally those data that would assist in obtaining answers to questions about O&S requirements as a function of alternative design concepts and/or approaches for system hardware and alternative support concepts. In this context, HRD includes information about manpower, skills, skill levels, reliability (R), maintainability (M), support equipment, spares, training, and technical manuals.

APPROACH

The approach taken involved four steps. First, the results of the previous three tasks of this overall study were synthesized and analyzed since the proposed development for the UDB is to be based on the results of these previous efforts. In general, these results addressed (a) the existing Air Force, Army, Navy, and other data bases which could feasibly "feed" the UDB, (b) the weapon system design and acquisition process, in order to later establish the requirements, potential use, and operational concepts for the proposed UDB, and (c) user needs, in terms of the adequacy of the data systems investigated.

Second, the concept of a UDB and a supporting DGTB was developed.

The DGTB is intended to generate generic data to fill in the needs of users where the data systems, and likewise the UDB, would leave voids. The DGTB would include various technologies that use standard analytical techniques (e.g., parametric estimating relationships, regression analysis, comparability analysis, expected value techniques) to provide initial data values in the very early stages of weapon system design until more reliable values emerge as a result of the system design and/or test process. This concept was found to be necessary during the first three tasks of the total study.

Third, a concept of operational use for the UDB/DGTB was defined. This, too, was based on the results of the first three tasks.

Finally, the technical approach for the development of a prototype UDB/DGTB was established. It was based on (a) the results of the first three tasks, (b) an investigation of the development process of other previous analogous but less-encompassing technologies (e.g., the Army Logistics Support Analysis/Logistics Support Analysis Record (LSA/LSAR), Boeing Aircraft Company's LSAR), (c) a prioritization of the data systems and data generating technologies investigated, and (d) an analysis of an industry survey which addressed the structure of a UDB/DGTB.

CONCLUSIONS

The following results are documented in this report:

1. A review of the first task (the data system review) indicated that the data are available, formatted, and standardized, thus making a UDB feasible from this standpoint.

2. A review of the second task (the weapon system design process) indicated that a realistic concept of operation for a UDB is feasible.

3. A review of the third task (identification of user needs) indicated that a UDB is needed and would be used.

4. A more detailed concept for a UDB and DGTB is developed.

The UDB would contain two different types of information. The first type would be information about an existing aircraft weapons system that most closely compares with the new aircraft system under development. The second type would be information about the new aircraft system under development. The latter would expand in time with the ever-increasing definition and design of the new system. The data format in the UDB should be compatible not only with the weapon system design and acquisition process but also with the testing, operational and support processes.

The DGTB should provide many initial values for the UDB elements. These initial values would be eventually supplanted by better values based upon more detailed design, hardware, and/or test information. It is quite conceivable that data in the UDB, associated with a comparable but earlier generation weapon system, would be used as input to the DGTB to obtain "next generation" initial values.

This concept is patterned somewhat after the Army's LSA/LSAR technology in that the format and standardization techniques are adapted, but are modified in accordance with guidance from an on-going tri-services LSAR working group. The idea of basing the UDB technology upon the LSAR was supported by the industry survey results. The resulting UDB concept is also patterned after the Logistics Composite Model (LCOM) and Common Data Extraction Program (CDEP) technology in that a central repository of data is maintained, updated, and kept traceable. It is maintained either on computer disc or in magnetic tape libraries. The success associated with an Air Force Avionics Laboratory technology called system avionics valve estimation (SAVE) also impacted the resulting concept for a UDB/DGTB. The DGTB concept itself was introduced successfully by SAVE.

5. A more detailed concept of operational use for the UDB/DGTB is defined. This concept is based primarily on the results of studying the weapon system design process and a more in-depth look at the industry survey. The UDB/DGTB would be used in the very earliest phase of weapon system design (conceptual phase) and would continue to be used throughout the acquisition process. Historical baseline data in the UDB would be used for comparability analyses at the outset of a new acquisition program. Similarly, the DGTB would be of more importance during the Conceptual Phase, since it would provide predictive data related to human resources and logistics support (HR&LS) factors. The UDB would provide space for recording the required, predicted, and demonstrated values for each important parameter of HRD related to the

new weapon system. Although these data would continually be updated, a permanent record would be provided (possibly on magnetic tape) at each major milestone of the Defense Systems Acquisition Review Council (DSARC). The users of the UDB/DGTB would be those government agencies primarily involved in the weapon system acquisition process, including their industry counterparts. The housekeepers of the UDB/DGTB would be the Air Force Acquisition Logistics Division (AFALD) of the Air Froce Logistics Command (AFLC).

6. Finally, the technical approach for the development of a prototype UDB/DGTB is established. This result represents the climax of the total study, as well as an integration of all previous results into a proposed plan of action.

The UDB/DGTB technology is evolving in the heuristic manner. At this stage of the development process, the initial outline for a UDB/DGTB can be identified. This outline is based on a prioritization of the more important data systems and technologies which the UDB/DGTB should accommodate. The more important data-producing systems for the UDB are listed by order of importance: LSAR, LCOM/CDEP, Air Force Guide-2, and an Air Force Test and Evaluation Center technology called OMNIVORE. The use of these four systems will require use of many other data systems discussed in AFHRL-TR-79-36 since these in turn "feed" the preceding four.

The more important technologies for the DGTB are ranked and include parametric estimating relationships (PER), expected value techniques, LSA, comparability analysis, optimal repair level analysis.

The UDB/DGTB technology development effort is scoped to be in three phases: (a) finalize the UDB/DGTB definition, an effort which will clearly define what data systems and what data generating technologies will be addressed in the prototype UDB/DGTB, (b) develop the software, and (c) test and demonstrate the software and its ability to meet the requirements of the UDB concept. Each phase will last about 1 year, and each phase will require about 3 work-years of effort.

The recommended process for the development of a prototype UDB/DGTB technology assumes a contractual effort. The contractor should submit performance plans that would be approved by a special Air Force advisory group at various milestones in the development process. This advisory group could quite feasibly be composed of those individuals on the tri-services LSAR working group, plus other selected individuals. The final UDB/DGTB description will depend on the "feedback" from this advisory group.

PREFACE

This study was conceived, scoped, initiated, monitored, and concluded by the Logistics and Technical Training Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio. The study was conducted under Project 1124, Human Resources in Aerospace System Development and Operations, Dr. Ross L. Morgan, Project Scientist. The Task was 1124-01, Personnel, Training and Manning Factors in the Conception and Development of Aerospace Systems, Dr. William B. Askren, Task Scientist. The Work Unit was 1124-01-10, Description of Weapon System Design Process and its Need for Personnel, Training and Logistics Data, Robert N. Deem, Work Unit Scientist. Appreciation is extended to these personnel of the Logistics and Technical Training Division of AFHRL for their guidance and encouragement throughout this effort. Apreciation is also extended to the many individuals of Air Force Logistics Command and the Acquisitions Logistics Division at Wright-Patterson Air Force Base, Ohio, who supplied information in support of this study. Without the support of Boeing, Fairchild-Republic, Lockheed-Georgia, Honeywell, Northrop, Rockwell, Texas Instruments, Vought, and Westinghouse, the data for the study would not have been available. These companies were extremely cooperative in identifying qualified respondents to complete the survey. Appreciation is also extended to the Directorate of Advanced Planning, Aeronautical Systems Division (ASD/XR) for participating in the survey and providing valuable information. Finally, to the 161 engineering respondents from industry, sincere appreciation is extended because without their specific, objective, and candid inputs the study would not have been possible.

This study was a cooperative effort between Clemson University and Lockheed-Georgia Company. It should be noted that Robert J. Hankins, a principal author, is with Lockheed-Georgia Company. Appreciation is extended to Hunter Sohn, Manager, Maintainability Department; without his direct and continuing support, this study could not have been successfully completed.

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SECTION I

INTRODUCTION

GENERAL

The primary objective of this study is to establish an initial plan for development of a Unified Data Base (UDB) of human resource (HR) related information for utilization in the weapons system acquisition process to influence system design. The output of this study will be four reports:

Report I: Thomas and Hankins (1980).

Report II: Thomas, Hankins, and Newhouse (1979a).

Report III: Thomas, Hankins, and Newhouse (1979b).

This report (Report IV) presents the basic plan and recommendations for development of a prototype UDB and Data Generating Technology Base (UDB/DGTB). The results of Reports I, II, and III of this study were used to develop the concept of the UDB/DGTB, the development approach, and the manner in which it should be used.

As used in this study, human resources data (HRD) refers to information for use during design/development phases that provides impact estimates or otherwise describes ground support human resource requirements (HRR) in the operation and support (O&S) phase of a weapon system. HRD are fundamentally those data which would assist in obtaining answers to the following questions about O&S ground support requirements as a function of alternative design concepts/approaches for system hardware and alternative support concepts:

How many people are needed?

What type of skills and skill levels are needed?

How available and perishable are the people needed?

How much will the people cost?

In the preceding context, HRD relates directly or indirectly to reliability and maintainability (R&M), personnel, training, technical data, manpower costs, test support equipment, and human engineering information--regardless of the source, form, and content.

The fundamental criteria that guided the study efforts leading to this report were as follows:

1. The UDB/DGTB is basically a system to support the design process in major weapon systems acquisition.
2. Existing historical data systems will be utilized to the maximum extent practical.
3. Established and validated data generating technology will be utilized to the maximum extent practical.
4. Duplication and redundancy of data and data systems will be avoided and reduced.
5. Consistency and compatibility of data elements will be insured so as to provide a common thread of HRD from the conceptual phase to deployment of a weapon system.
6. Modifications required of existing data systems and technology will be consistent with satisfying user needs and the other criteria.

While "satisfying validated user needs at minimum cost" is not stated as a specific criterion, a UDB/DGTB that satisfies the criteria listed will significantly reduce the overall cost of data collection, reduction, processing, analysis, and reporting by government and industry during research, development, test, and evaluation (RDT&E). More importantly, the UDB/DGTB should ultimately result in significant reductions in O&S costs for weapon systems without sacrificing required operational effectiveness.

CONTENTS OF REPORT

This report is divided into four major sections. Section II integrates the results of Reports I, II, and III of this study and presents the major findings and conclusions. Section III presents the concept of a UDB/DGTB. Section IV presents the concept of operation of the UDB/DGTB and how each user could utilize the system. Section V presents the development approach for the prototype UDB/DGTB.

SECTION II

CONSOLIDATION OF PREVIOUS STUDY REPORTS

GENERAL

In order to establish an initial plan for the development of a UDB, three prerequisite tasks were accomplished and documented in Reports I, II and III mentioned in Section I. Report I identifies existing data and data systems that relate to HRD and that are useful in the system design process. Report II describes the weapon system design process with specific emphasis on the utilization of HRD to influence hardware design. An industry survey was used to provide input data for this effort. Report III considers the adequacy of existing HRD and the identification of new and/or modified HRD for use in various phases of system design, and an assessment of some existing data systems and selected data generating technologies (DGT) which were introduced in Report I. Again, the industry survey was used to provide input data for this effort. This section synthesizes and summarizes the major findings and the results of Report I, II, and III.

EXISTING DATA/DATA SYSTEMS

Several data/data systems being utilized by the Air Force are directly related to HRD and could be useful and usable in the system design process. These include the base level maintenance data collection system (MDCS), base level maintenance cost system (MDS:H-129), aerospace vehicle inventory status (GO 33), weapons system effectiveness programs and models (KO 51), USAF cost and planning factors (AFR 173-10), Logistics Support Analysis (LSA) (MIL-STD-1388-1), unit costs of aircraft, guided missiles, and engines (TO 00-25-30), standard aircraft characteristics (Air Force Guide-2), group weight statements (AN-9103-D) and systems effectiveness data system (SEDS). While the primary source of HRD is without doubt the existing MDCS and the Air Force Logistics Command (AFLC) by-products generated from this source data, the other data sources are also very useful as they apply to the development of a comprehensive historical data base for future weapon systems programs. This is particularly true of the LSA and resulting logistics support analysis record (LSAR) system after it has been applied to specific acquisition programs.

All in all, there is an enormous volume of operation source data related either directly or indirectly to HRD. Existing operational data systems use these source data to generate many by-products for logistic support planning, budgeting, and management of all levels within the Air Force management structure.

HUMAN RESOURCES TECHNOLOGIES

Much research has been or is being conducted to develop technologies that will enable human resource and logistics support (HR&LS) factors to influence weapon system design and development. Specific technologies identified fall into the areas of HR&LS as design constraints, HR&LS in design trade-offs, computerized HRD for system design, HR&LS requirements prediction (analytic and simulation techniques), HR&LS design handbooks, and life cycle costing models.

The area of HR&LS as design constraints is concerned with the feasibility of using HR&LS parameters to establish "design to" requirements for system hardware. Studies by Shapero and Bates (1959); Hannah, Boldovici, Altman, and Manion (1965); Hannah and Reed (1965); Snyder and Askren (1968); Lintz (1973); Potter, Korkan, and Dieterly (1975a); and Askren (1976) developed techniques for using HR&LS factors an engineering design criteria. Six studies by Meister and Farr (1966); Meister and Sullivan (1967); Meister, Sullivan, and Askren (1968); Meister, Sullivan, Finley, and Askren (1969a, 1969b); Meister, Finley, and Thompson (1971) resulted in valuable knowledge and insights about how designers perceive HR&LS factors, and how HRD are and can be used in system design. Meister concluded, among other things, that (a) HRD is used by designers but the influence on design varies considerably, (b) the more detailed the HRD, the more weight it receives in design decisions, and (c) the extent to which HRD influences design is a function of its quantity, quality, and availability.

Numerous studies have investigated the feasibility of considering HR&LS factors in design trade-off analyses. Askren and Korkan (1971);

Askren, Korkan, and Watts (1973); Askren (1973) developed the design option decision tree (DODT) approach and demonstrated that early design trade-off studies frequently impact HR&LS factors. Lintz, Askren, and Lott (1971); Walen and Askren (1974); and Potter, Korkan, and Dieterly (1975b) advanced the works of Askren by studying applications of DODT to other areas of system hardware.

During the 1960's, studies by Reed, Foley, Graham, and Hilgeman (1963); Whiteman (1965); Tulley and Meyer (1967); Potter, Tulley, Reed, and Lawrence (1968); and Reardon (1968) were accomplished to computerize HRD for use in system design. This effort concentrated on the generation and flow of HRD in the design process using network diagrams. Apparently lacking support, the emphasis in the 1970's shifted to prediction of HRR by means of computer simulations. The coordinated works by Drake (1974); Hicks and Tetmeyer (1974); Maher and York (1974); Moody, Tetmeyer, and Nichols (1974); Tetmeyer (1974); Tetmeyer and Moody (1974); Tetmeyer, Nichols, Hart, and Maher (1976); and Tetmeyer, Nichols, and Deem (1976) resulted in the development of sophisticated and effective simulation techniques for considering and predicting HR&LS requirements. Today, simulation techniques are increasingly used to predict integrated logistics support requirements for weapon systems. The Logistics Composite Model (LCOM) is the most current model and is frequently used in the Air Force, although its effective use in the conceptual phase is limited by the lack of system design definition.

HR&LS requirements prediction via analytical techniques has been increasingly applied in the area of system design. Purvis, McLaughlin, and Mallory (1964); and Purvis, Mallory, and McLaughlin (1965) investigated the use of queueing techniques to determine manning and related support requirements. Mills, Backert, and Hatfield (1975) investigated human performance in terms of task performance reliability and time. Forecasting techniques developed by Widenhouse and Romano (1977) focused on operational reliability and maintenance support. The most promising developments for application to the early stages of weapon system design have been in the area of cost and parametric estimating relationships (CER/PER). Work by Hankins (1978) is representative of the advancements that have been achieved in developing CER/PER models that can be used during the conceptual and preliminary design stages of acquisition programs.

In the area of HR&LS design handbooks, Boeing Company (1975) developed an approach for specifying training and training equipment requirements. Reed, Snyder, Baran, Loy, and Curtin (1975) developed a prototype design handbook that addressed a wide range of HR&LS data, and Meister (1976) found that it would be most helpful to expand the availability and use of HR&LS design handbooks.

The Air Force Human Resources Laboratory (AFHRL) has sponsored numerous projects to develop improved technology in the area of job guide design. Works by Foley (1972, 1973) and Joyce (1973a, 1973b, 1973c) are representative of the major advances that have been made to improve maintenance technical orders and job performance aids.

Many life cycle cost (LCC) models have been developed to predict and control acquisition costs and costs of ownership. Gibson (1975), Menker (1975) and Collins (1976) have developed a library of LCC models and guides for using them. The models most frequently used by the Air Force in weapon system acquisition programs are the cost analysis/cost estimating (CACE) and the logistics support cost (LSC) models (Thomas and Hankins, 1980, pp. 97-101). Important studies by Cerone (1972); Cork and Mucahy (1977); and Czuchy, Glasier, Kistler, Bristol, Baran, and Dieterly (1978) have produced cost of ownership models that could be effectively utilized in the system acquisition process.

The recent AFHRL efforts by Goclowski (1978a, 1978b, 1978c) to develop criteria for a Consolidated Data Base (CDB) to support the coordinated human resources technology (CHRT) are directly related to the AFHRL efforts by Clemson University (Thomas and Hankins, 1980 and this report). It is believed that the CDB should be, to the maximum extent possible, an integral part of the UDB described later in this report, and further, that the CHRT should be incorporated into the DGTB, as appropriate.

Overall, the available HR technology, and its associated literature, is extensive. The collective work of AFHRL is clearly representative of the current state of the art in this area. The technologies developed by AFHRL demonstrate that HRD can be used to influence the design of complex system hardware. When viewed in the light of a total weapon system development program, however, the existing data base to support these technologies is critically underdeveloped.

THE WEAPON SYSTEM DESIGN PROCESS

Current Department of Defense (DOD) documentation was reviewed to provide an overview of the weapon system design process during the conceptual and validation phases of an aircraft research, development, test, and evaluation (RDT&E) program. A comprehensive industry survey was conducted to define specific activities, documentation, and the extent of subsystem design accomplished during these early program phases. In addition, the survey was used to obtain inputs to determine the availability, utilization, adequacy, and source of HRD used in the design process.

A separate questionnaire was prepared for three types of engineers --chief/project engineers (PE), design engineers (DE), and R&M/integrated logistic support engineers (ILS). Of 15 companies contacted, 9 agreed to participate in the study. Table 1 shows the number of respondents according to the companies' primary product type and type engineer.

TABLE 1. SURVEY RESPONDENTS

	Type Engineer			
Type Produce	PE	DE	ILS	Total
Fighter	11	39	10	60
Bomber	7	28	8	43
Transport	4	16	10	30
Avionics	6	17	5	28
Total	28	100	33	161

The survey results show that, during the conceptual phase, operational and support scenarios/plans are established, weapon system performance specifications are defined, and top-level system and subsystem design is completed. Early validation phase activity includes preliminary design of the airframe, propulsion and other subsystems affecting overall system performance. This activity includes interface definition, integration top-level drawings and schematic diagrams. By the end of the validation phase, the performance specifications for all subsystems are established and documented. When prototype demonstrations are involved, detailed design, fabrication, and testing of mission-critical subsystems are accomplished in the validation phase.

Regardless of the management approach used, the majority of all major design decisions will have been made by the end of the validation phase. The conceptual design phase (CDP) coincides with the conceptual phase of a program, while the preliminary design phase (PDP) generally coincides with the validation phase of a program. Strictly speaking, the conceptual phase includes all CDP and some initial PDP activity, while the validation phase includes the remaining PDP and some initial detailed design phase (DDP) activity. Throughout the CDP and PDP, design trade studies represent the best mechanism whereby human resources factors (HRF) may be considered to influence system hardware design decisions.

The major engineering activities and documentation completed in the CDP include relatively little emphasis on HRR. When attention is given to HRR, it generally occurs in trade studies. It should be noted that in this report, trade studies refer to conceptual trade-off, parametric trade-off, or design trade-off studies. During the PDP, increased emphasis on HRR occurs but it is still a relatively small amount. The primary mechanisms to consider HRR are R&M engineering and trade studies. The analysis revealed that LSA is not usually initiated until after PDP has been completed.

The degree to which subsystems are typically designed during the CDP and PDP was identified for several work unit code (WUC) levels. These results may be useful in the future to identify areas and levels of hardware design activity in the early phases, thereby assisting in determining the type, level, form, and content of HRD that may be useful to support these activities.

TRADE STUDIES

The 161 survey respondents identified 3,778 representative trade studies accomplished during the CDP, PDP, and DDP. Trades were analyzed within each design phase according to category (conceptual, parametric, design), concept (operational concept, support concept, hardware concept), engineer (PE, DE, ILS), and product (fighter, transport, bomber, avionics).

More than 80% of all important system and subsystem level trade studies conducted for a weapon system acquisition program are conducted during the CDP and PDP. Of the trades conducted in the CDP and PDP, 22% relate to high-level conceptual trades early in the CDP, while the other 78% address parametric and design trades that relate to specific system hardware alternatives. This finding clearly shows the importance of the development and use of high-level PER/CER to influence the design process. O&S HRR (ground support) are impacted by at least 70% of all trades in the CDP and PDP.

Analyses of trade studies by various breakdowns may influence the UDB effort in terms of the form/content and level of data elements. For example, hardware concepts dominate PE and DE trade studies, while ILS types are split between hardware and support concept trades. Operational trades occur early in the process, primarily by PEs and DEs. Support concept trade studies increase as the design process progresses and are conducted primarily via logistics support analyses. Because PEs and DEs are primarily concerned with hardware concepts and greatly outnumber ILS engineers, there is a need for a UDB to supply all engineers with HRD to influence trade studies throughout the design process.

Another factor which may influence the UDB effort is the level of trade study activity between products. During the CDP and PDP, the level of trade studies, and thus the level of HRD necessary to support the studies, between products is relatively constant. Of particular significance, however, is that fighter aircraft product engineers accomplish more total trade studies and 34% more hardware trade studies per capita than do other product type engineers. At the same time, fighter types accomplish less than 40% of the per capita support concept trades done by other product type engineers. Thus, while fighter aircraft, by complexity and sheer numbers, represent the largest HR impact, their design is least responsive to trade studies involving O&S impacts.

HUMAN RESOURCES FACTORS

An important consideration in the development of a UDB is the degree to which human resources factors (HRF) are considered. Table 2 shows the percentage of total trade studies for CDP/PDP which consider a particular HRF.

Reliability and maintainability are the HRF most frequently considered, with ground support equipment (GSE) and ground support manpower costs (MP COST) coming in a distant second. Technical data and built-in-test-equipment (BITE) are the HRF considered least in trade studies. Many HRF are considered in only 30% of the trade studies.

TABLE 2. CONSIDERATION OF HRF--
PERCENTAGE OF TOTAL TRADES

HRF	Trades Which Consider a HRF, %			
	DE	PE	ILS	Total %
Reliability	65.15	71.63	83.33	70.78
Maintainability	68.08	74.47	79.06	72.05
GSE	36.04	53.05	57.83	44.90
BITE	21.34	32.91	41.31	28.54
Task Analysis	24.03	37.73	42.74	31.43
Skills	23.25	35.46	32.91	28.25
Skill Level	26.78	33.62	32.62	29.68
Crew Size	25.40	44.68	36.61	32.37
Training Requirements	29.23	33.90	33.48	31.27
Technical Data	24.81	28.09	32.76	27.37
Manpower Costs	41.42	47.94	65.38	48.38
Human Factors	35.68	39.86	34.33	36.33
Total Number of Trades Considered	1653	705	702	3080
Total Number of Trades Impacting HRR	1079	510	579	2291
Percentage of Total Trades that Impact HRR	64.5%	72.3%	82.5%	74.4%

To a significant degree, DE consider HRF in trade studies less frequently than do PE and ILS. It is surprising to note that PE consider skills, skill level, crew size, training requirements, and human factors in trade studies more frequently than ILS. It is also surprising that 8 of the 12 HRF are considered in less than 43% of all trade studies by ILS.

In the 3080 trade studies identified for CDP/PDP, 2291 (74%) were judged by DE, PE, and ILS to impact HRR. Thus, it is seen that while individual HRF are not being considered in the majority of trade studies, engineers clearly recognize that these trade studies involve downstream O&S impact on HRR.

The importance placed on each HRF during a trade study is useful data for designing UDB data elements. In addition to identifying the HRF actually considered in trade studies, as shown in Table 2, the survey engineers also identified the factors they considered most important in each trade study. While 187 discrete factors were identified, the top 15 account for over 50% of the total number of times that all important factors were mentioned for all trade studies. These top 15 important factors were: weight/weight allocation, acquisition cost, reliability, maintainability, subsystem requirements, system performance, R&M/availability, life-cycle cost, subsystem design concept, maintenance requirements, hardware design/performance requirements, manpower (number, skills, levels), survivability/vulnerability, support equipment, support concepts. Eight of these top 15 factors are HR related and account for 22% of the total number of times that all important factors were mentioned for all trade studies. Thus, it is seen that while some HRF rank very high in importance for all trade studies, others such as BITE, training requirements, and technical data are rarely considered important. There is an apparent contradiction in the level of importance placed on skills, skill level, crew size and GSE, and the degree to which they are actually considered in trade studies. While they are considered among the top most important factors to be considered, Table 2 shows that they are actually considered in less than 30% of the CDP/PDP trade studies. As will be discussed later, the reason appears to be the lack of timely and useful data in these areas.

SOURCES OF HRD

When HRF are considered in a trade study, data are supplied generally by functional organizations only when requested by the design team. When adequate data are provided, the following sources provide them 96% of the time: company/support engineering (66%), Government/Air Force (14%), design engineering (6%), vendors (6%), other company data (4%). Overall, company data are used much more frequently than are AFLC data; however, it is not known how much of the company data are obtained from the AFLC data tapes.

AVAILABILITY/ADEQUACY OF DATA FOR USE IN WEAPON SYSTEM DESIGN

Data from the trade study analyses were combined with additional survey data to evaluate the availability and adequacy of existing HRD to influence system design. As programs evolve through CDP and PDP, HRF are increasingly considered, but the increase is relatively small.

Sixty-six percent of all ILS engineers stated that the availability of HRD for use in all RDT&E is limited but satisfactory. Fighter aircraft ILS engineers are more inclined to believe data availability is satisfactory than are other product type engineers.

Sixty-one percent of all ILS engineers stated that the adequacy of available HRD is unsatisfactory. Again, fighter aircraft ILS engineers disagree with the other product type engineers: 70% indicate the adequacy of HRD is satisfactory. It should be noted that on a per capita basis fighter aircraft engineers conduct 40% fewer support concept trade studies than do the other product type engineers. If the data are not used, existing inadequacies will not be recognized.

Regarding overall adequacy of HRD for use in the CDP, 52% of the PE and ILS respondents say the data are inadequate. The results are generally applicable to the PDP as well.

PROBLEMS IN USING HRD IN CDP/PDP

The industry respondents specifically stated that the top three major problems associated with using HRD to influence design in the CDP are (a) lack of useful/usable data, (b) insufficient time, funds, priority, and (c) inadequate design definition. In the PDP, the top three problems are (a) lack of useful/usable data, (b) company organization and attitudes of engineers, and (c) limited need and applicability for design. Specific industry recommendations to correct these problems, listed by percentage of time mentioned are (a) general and specific HRD improvements (48%), (b) increased government (customer) emphasis and priority (26%), (c) organizational/functional responsibilities (1l ͅ), and (d) education and training of engineers (6%).

ADEQUACY OF DATA TECHNOLOGIES (SURVEY)

Of 93 DEs responding, 76% stated a preference for a UDB of HRD to provide information to influence design. Regarding the required use of MIL-STD-1388 on all major weapon system programs, 47% of all respondents approved, 19% disapproved, 31% did not know and 3% failed to respond. Regarding improved compatibility between LSAR and WUC, 52% of the industry considers this desirable, 6% undesirable, 13% insignificant, and 28% either having no opinion or failing to answer.

All respondents were asked to respond to a question regarding making the work breakdown structure (WBS) more compatible with the WUC structure: 65% of respondents favored more compatibility, 22% disagreed with the notion, and 17% did not answer.

Several disadvantages tc making WBS compatible with WUC were listed (in order of decreasing frequency): administrative and organization problems of cost accounting and management control, inherent incompatibility of WBS and WUC, complexity of accounting and documentation system, resistance to changing the current system, difficulty of using historical data for cost estimating, additional cost of accounting systems, and negative impacts on design and technical areas. In spite of these disadvantages, the industry respondents appear to be highly in favor of greater WBS/WUC compatibility. Advantages to this sort of system fall into these major categories: better correlation of design effort to system performance, better cost estimating/control/

accountability, utility of historical data, greater system commonality, and improved LCC estimating and trackability.

RECOMMENDATIONS TO RESOLVE PROBLEMS IN USING HRD

The DE and ILS engineers were asked to "Provide any suggestions/ recommendations you may have to help resolve the problems associated with utilizing HRD in the conceptual and preliminary design phases."

Customer (Government) Emphasis and Priority

Some of the more significant suggestions/recommendations fall in the area of "Customer (Government) Emphasis and Priority," and are included here because of their importance to the future development of a UDB.

1. "A company could afford to address this problem only if it were sure all competitors were also going to be forced to spend the time and money considering O&S manpower requirements and, where necessary, compromising their design because of it. Merely making accurate HRD readily available would not be enough. Specification requirements would have to force it."

2. "HRF must be given as much weight as other factors in the evaluation of a contractor's performance. Because of budget, enough money is never available to do everything that should be done and HRF considerations take second place to aircraft basics."

3. "Resolution is of course to make the objective of reliable, maintainable, and reasonable LCC a reality that is visible, emphasized, and paid for. When such efforts are asked for but their cost is effectively used against the bidding firm in the price competition, then their position is really subordinated to performance and no actual HRD except the minimum is involved."

4. "O&S requirements should be integrated from the beginning with those for the design evaluation and development process; e.g., design, stress, loads, tooling, test, etc."

5. "Provide specific requirements for HRD and to what extent performance, weight, safety and R can be compromised to meet HRD requirements. In most cases these requirements will be in conflict."

6. "Top level DOD/AF emphasis on design-to-cost (DTC) and LCC and related publicity will help, particularly if contracts are sometimes awarded to the apparent high bidder based on a significantly lower O&S cost. On contracted studies, the problem can be resolved by including appropriate support tasks in the statement of work."

7. "Air Force must follow through with support planning in the conceptual phase. Funding must be provided and sustained for this purpose. Current policy involves allocating funds for both O&S systems. Support funds are always transitioned to the operational system development effort."

8. "Expressed willingness by DOD/AFLC to invest their resources in support early-on coupled with AFALD participation will help. Firm requirements in the statement of work will fix it for sure."

These suggestions/recommendations appear to best represent the consensus of the industry. Responses generally indicate that the customer must incorporate into procurement documentation the requirements and funds to consider HRD in the CDP and PDP. Until this is effectively accomplished, there is simply no incentive, opportunity, or advantage to the contractor for attempting to effectively incorporate the use of HRD in early design decisions. Moreover, the DTC requirements, if imposed, may require design decisions to drive acquisition costs down while simultaneously driving ultimate O&S costs up. These potentially opposing objectives (i.e., lower DTC and lower O&S costs) must be recognized and balanced by the customer.

General Improvement of HRD

The second most significant area addressed falls in the category of "General Improvement of HRD." The following comments are presented here because of their potential value in the selection of data generating technology to be incorporated into the DGTB. These comments strongly support the need for a dramatic increase in CER/PER to support the design process.

1. "Estimating or computational techniques used for HRD. Conceptual phase values must be sensitive to design/performance parameters

used consistently during CDP and PDP. In addition, the technique must:

a. provide realistic values that can be achieved and demonstrated in actual operational units, and

b. respond to design technology improvements, simplified installations, and planned access provisions. The only difference between the two phases (conceptual/preliminary design) is that the design/performance parameters can usually be identified to the subsystem level during preliminary design and are usually better defined."

2. "Fund studies to correlate data available through AFM 66-1 to performance and equipment design characteristics. Make results available to all contractors. Expand data available in AFLC Pamphlet 800-4 to include all WUCs to five digit level. Make data available to all contractors with a need to know."

3. "If studies could be done of existing weapon systems, using the quality of design available at their inception, then these estimated HRD could be compared to actual manhour expenditures. If reasonable correlation is obtained, these results could be used to gain credibility."

4. "I think if someone could compile a set of basic system descriptions that would characterize all of the essential elements of a system that related to HRD, so a designer could establish similarity for whatever phase he is in, and then compile prediction/analysis and field data for those systems, and put the information in some sort of form where it was immediately accessible, that tremendous improvements would result."

5. "Inadequate Technology: More research is required into the failure modes of aircraft equipment, the environmental cause of failures and design parameters or details. Likewise, more research is required into the exact nature of maintenance actions and design characteristics. For many systems, as much time is consumed in diagnostic activities, no removals, and minor repairs as is spent on repair of relevant failures."

6. "Stress placed upon performance: The relationships between operational readiness, sortie capability, and success of combat mission should be established early in the design stage. Parametric relationships must be used if appropriate trade-offs between R, M, and conventional performance parameters are to be accomplished. Further, these considerations should be incorporated in all DTC trades."

New/Improved HRD

The following comments are from specific recommendations for new/improved HRD:

1. "Data that would permit maintenance cost at an early stage, if it could be generated in a believable fashion, would help increase the impact on design decisions at an early stage. However, such data needs to be believable. Today, even in the operational phase, the O&S cost projections used for value engineering studies is constantly being questioned, often by the people that generate the data."

2. "Maintenance manhours/flight hour (MMH/FH) for various systems--sufficient to give relative indicators on aircraft weight, crew size, number of engines, density of packaging, avionics equipment, armament (number of store stations), pod mounted versus buried engines, fixed versus variable swept wing, integral fuel tanks versus bag (bladder) tanks. Publishing data on existing systems with analysis identifying prime drivers for difference between similar systems would be extremely helpful."

3. "At the total system level, it would be desirable to have reasonable HRD information when almost no detail of the system is known. There are routines that will give program prices when all that is known is weight, speed, number of units to be procured, engine thrust, number of engines and fuel load are inputed. A similar HRD estimate would upgrade LCC estimates at this early stage of a program."

4. "A specific conceptual phase computer program which would allocate statistical R&M parameters among the major air vehicle elements and subsystems as a function of design parameters known at that time which is sensitive to concept variations. The allocation buildup to be printed out for analysis, as weights and costs are now."

5. "Sensitivity data for O&S costs as they vary for changes in significant weapon system performance parameters, such as gross weight, speed, range, number of engines, etc. Even qualitative data to guide the concept analyst during early trades."

6. "A computer model that provides O&S costs or variations in cost as a function of major weapon system performance parameters or basing concepts."

7. "Need trade-off tables or curves to show O&S and LCC impact on manpower requirements as a function of the number of LRU, SRU, and hardware/software partitioning."

8. "A graphic illustration that indicates in some manner the relationship between system tolerances, complexity, percentage new development, etc.; such that systems under consideration can be plotted to obtain relative merit and risk for each alternate."

9. "A chart or series of charts (nomograms) that allow gross trades in a given system between performance requirements, R, M, initial costs, and LCC."

10. "Historical data on MMH/FH (total weapon system, system and subsystem) versus availability, O&S cost plus any other M quantitative parameters that relate to performance and cost. HRD is needed that can establish credible relationships between <u>actual</u> M requirements, operational availability (A_o), and O&S real-world results."

Here again, the recommendations are representative of the overall consensus of the industry as to the type of HRD most needed to support CDP and PDP trade studies with emphasis on CERs and PERs.

SECTION III

CONCEPT OF UDB/DGTB

GENERAL

This section describes the concept of a UDB and a unified DGTB. Section IV provides an overview of the weapon system design process and how the UDB and DGTB could be utilized to support all phases of an aircraft weapon system acquisition program. It is emphasized that the concept of the UDB and DGTB, as discussed in this section, is broader in scope than the specific prototype development effort recommended in Section V. The purpose of discussing the broader concepts of a UDB and DGTB is to insure that the prototype development effort provides the appropriate foundation and framework upon which future development efforts may be accomplished in a modular or building block manner.

PURPOSE AND OBJECTIVES

The UDB and DGTB can be thought of as two separable but closely interrelated data bases. It is very important to understand the purpose and objectives of each and how they are interrelated.

PURPOSE OF DGTB

The primary purpose of the DGTB is to provide a means whereby useful and usable HR information can be brought to bear so as to influence the design process, primarily during the conceptual and validation phases of a weapon system acquisition program. Thus the DGTB is basically a "design tool" - a mechanism to provide HR related information to support trade studies and design decisions during the conceptual and preliminary design stages. The information provided through the DGTB will, as a function of trade study alternatives, predict O&S HRR (logistics related). The objective of the designer, in using the DGTB, will be to consider the impact of a design decision on O&S HR and logistic support requirements.

PURPOSE OF UDB

The primary purpose of the UDB is to provide a consistent and trackable information record for a particular weapon system as it progresses through the acquisition process. The information contained in the UDB for a given weapon system will be HR&LS related. The UDB will contain standard data elements, thus permitting systematic analysis and documentation throughout the design/development, production, test, and evaluation process for a weapon system.

Objectives of UDB

The UDB is intended to satisfy three major objectives. The first is to provide a means whereby the HR&LS information, that evolves during the weapon system design process, can be developed in a consistent building block manner. This should significantly improve the continuity and compatibility of the data base to support multiple logistics efforts during acquisition. It should also reduce duplication of effort, improve planning and cost estimates, and result in greater system effectiveness.

The second major objective of the UDB is to provide a single thread of HR&LS related information that will provide a consistent audit trail from the CDP through the O&S phase of a weapon system program. This would permit trackability of the UDB from initial predictions in the CDP, to allocated requirements during validation and full-scale development (FSD) phases, to the demonstrated results during operational test and evaluation (OT&E) during production and early deployment, and finally to the field data collected in the O&S phase of the weapon system. This single thread enables the Government and industry to realistically determine how well a weapon system met its objectives, and will improve cost-effective planning for the O&S phase of the weapon system.

The third major objective of the UDB will be to provide a source of information for use in future weapon system acquisition programs. If a future weapon system is similar to the one for which a UDB exists, the use of such a UDB will provide an invaluable source of experience data to support design decisions for the future weapon system.

Thus it is seen that the DGTB provides information to help make knowledgeable and sound decisions throughout the design process for any given weapon system. The UDB records relevant information related to these decisions for a particular weapon system, assists in planning, helps to eliminate duplication of effort, provides an audit trail, and provides experience data for use in future acquisition programs.

INTERRELATIONSHIPS

The interrelationship between the UDB and DGTB will now be discussed. As stated above, the DGTB is basically a "design tool" to support the design/decision-making process for any given weapon system under development. As such, it must be developed so as to be generic in nature. Otherwise, it would be necessary to develop a DGTB for each new weapon system acquisition program. The DGTB will, therefore, contain standard programs, and techniques to retrieve data from various existing data systems, process the data as required, and provide outputs to users as needed. In addition, the DGTB will contain selected data-generating technology programs and files to provide specific data to users as needed. The DGTB will not be a historical data base, per se. It will provide storage, as required, only for new data generated, but it will not duplicate existing historical data base capabilities and functions.

Since the DGTB is generic in nature, it will not store data for a particular weapon system. The UDB provides the means whereby users can input weapon system data to be operated upon by specified programs in the DGTB to satisfy user requirements. This will include programs for processing LSAR data, providing data to feed other programs such as LCOM, Optimum Repair Level Analysis (ORLA), AFLC interfacing systems, etc. The outputs of the DGTB must, therefore, be consistent and compatible with the UDB data elements. When a Systems Program Office (SPO)/Air Force Acquisition Logistics Division (AFALD)/contractor makes a design decision that involves HR&LS factors, relevant information regarding same will be stored in the UDB.

It is assumed that operational responsibility for the UDB and DGTB will be assigned to AFALD. Since both systems will share common hardware and software, the UDB and DGTB essentially constitute separable parts of a single system. Figure 1 shows the concept of the UDB and DGTB in terms of the basic system components, objectives, functions and interrelationships. Note that a UDB file would be established for each weapon system under development. A detailed schematic and flow diagram of the UDB/DGTB operational concept is presented in Section IV.

DESCRIPTION OF DGTB

The DGTB will provide standardized procedures for compiling historical data for specific applications and support in the system design process. In addition, the DGTB will contain programs which represent the best and most efficient technologies to support all stages of system design. The historical data bases and data generating technologies will be identified from the results of the Clemson study (Thomas and Hankins, 1980) and from further literature research during the early phase of the prototype UDB/DGTB effort. It is envisioned that the DGTB will ultimately include procedures and techniques for estimating a wide range of HR requirements as a function of design alternatives during the CDP, PDP, and DDP of any given weapon system. For example, the DGTB would ultimately provide the capability to establish initial estimates for training, job guide, skills, skill levels, task times, personnel costs, support equipment, tools, and training equipment requirements as a function of design alternatives in a particular design stage of a fighter, bomber, transport, or training aircraft system in RDT&E. The extent to which the prototype DGTB will provide these capabilities will depend on (a) the extent to which existing historical data can be utilized, (b) the extent to which existing DGT have been developed, and (c) the constraints of time and resources for the prototype development and effort.

DATA GENERATING TECHNOLOGIES

LCOM/CDEP

LCOM will become an integral part of the DGTB technologies and capabilities, as will the common data extraction programs (CDEP). The

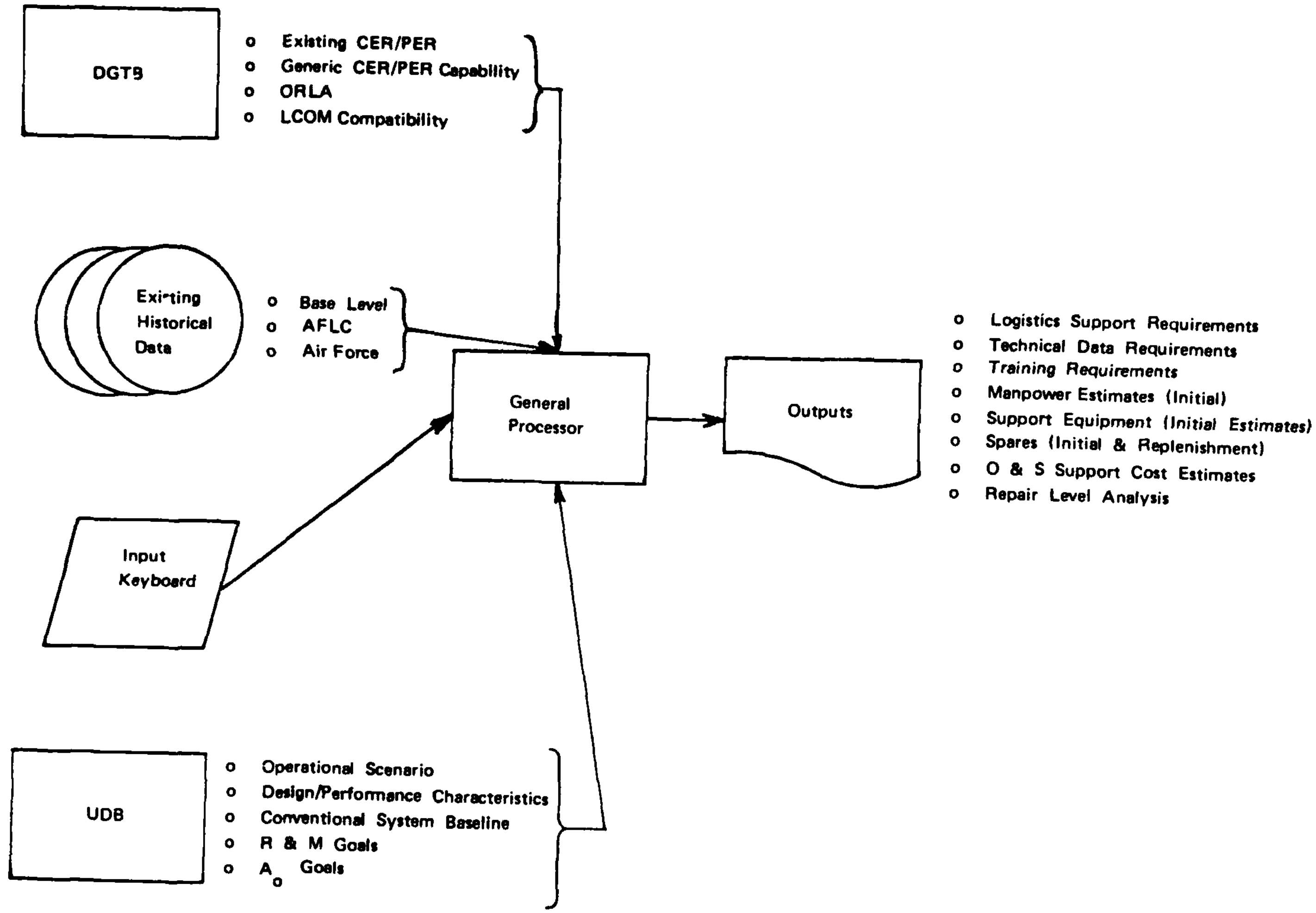

Figure 1. UDB/DGTB INTERFACES

data base that has been developed for use by LCOM will, to the maximum extent possible, be utilized by the DGTB. It appears that it will be necessary to reformat the input of LCOM for consistency with the LSAR format of MIL-STD-1388.

Other Data Generating Technologies

The DGTB will incorporate the use of other technologies such as CER, PER, method for evaluating A_o, method for adjusting manpower requirements for weapon system utilization level, method of assessment and optimization of inspection requirements, and a method for constructing multiple regressions into nomograph form that can be used in design trades.

MAJOR FUNCTIONS OF DGTB

The major functions of the DGTB are as follows:

1. Retrieves source data from existing data systems.

2. Processes data in a systematic, uniform, and consistent manner; for example, the CDEP.

3. Processes source data so as to provide outputs in standardized form and content for specific putposes; i.e., R&M parameters for the purpose of conducting R&M impact trade studies for different design approaches (parameters consistent with ARF 80-5 terms).

4. Provides data on call to authorized recipients.

5. Provides generic standardized design/performance characteristics data; i.e., AFR-2 type data.

6. Provides standardized data processing and storage of new data for input to the "specific" UDB; i.e., LSAR data.

7. Provides Generic CERs/PERs for specific estimates; i.e., initial spares cost - the estimating equations and parameters would be output - the users would use their own parameter values to derive an estimate.

8. Provides file maintenance and up-date programs.

9. Provides regression analysis program - available on demand for use by authorized users to operate on their own data file or from data provided from existing data systems.

10. Provides interfacing/processing programs for AFLC data systems such as D-195, D-220, etc.

11. Provides a standardized methodology for the selection of systems, subsystems to be used as the historical baseline for proposed new equipment and performing the comparability analysis - some may (will) be standardized and will consistently and systematically be followed each time a comparability analysis is performed.

12. Provides certain Air Force data, such as job descriptions for maintenance Air Force specialty codes, and functional application for the specialty code; i.e., pneudraulics, autopilot, mechanical accessories repair, fuel cell repair, etc.

13. Another consideration might be to have certain computer capability at the user site, in conjunction with the remote terminal, where the users could input their own historical data (AFLC data for example) and call up the programs from the generic data base to operate on the data. This approach would still provide standard, consistent, and uniform data to support RDT&E in that the programs used to process the data provide the uniformity and consistency. The R&M data provided in the AFALDP 800-4 are a good example. The format in which the data are presented breaks out into inherent, induced, no-defect, and total - then both the events and manhours are broken out by organization level (line) and intermediate level (shop). The program that processed those data has the decision logic built in to make the breakouts displayed. Therefore, any time R&M data are required from historical data the output is consistent in the segregation of the events and manhours and conforms to AFR 80-5 program management terms for R&M parameters.

DESCRIPTION OF THE UDB

The UDB, or specific weapon system data base, is the information record that evolves during the design process for a given weapon system program. The UDB will contain HR related estimates and characteristics of the weapon system, and will utilize MIL-STD-1388, LSA and the resulting LSAR as the major source of data elements. However, other relevant weapon system information will be a necessary part of the UDB.

CONCEPTUAL PHASE

Initially (in the CDP), the UDB may contain specified program requirements, specified goals, basic O&S concept data, top level design parameters (gross weight, speed, range, payload, etc.), and other data that may be relevant to O&S ground support HR requirements. As conceptual design progresses and system definition evolves, information filed in the UDB will expand accordingly. By the end of the CDP, the initial system specification (functional baseline) for the weapon system will have been established/documented, and the initial baseline of HR&LS information will be stored in the UDB. To a large extent, these data will be high level parametric estimates of HR&LS requirements. These high level parametric estimates are predictions of the weapon system performance and/or requirements in terms of R&M manpower, training, training aids, support equipment, costs, etc. during the O&S phase.

VALIDATION PHASE

As the weapon system progresses into the PDP (validation phase), the UDB continues to expand as the level of detail of the weapon system design definition increases. The UDB will continue to file the earlier baseline information and will build upon those data at the subsystem levels. LCOM outputs will be stored in the UDB as they become available. As the LSA increasingly comes into play, the outputs are stored in the UDB. All of the UDB information will be compatible and consistent to permit optimum utilization and avoid duplication of effort.

FULL-SCALE DEVELOPMENT PHASE

The UDB is expanded to its full level of detail as the weapon system progresses through DDP (full-scale development) and detailed LSARs are input. At this time, more detailed training, training equipment, job guide (technical data), support equipment, and ORLA requirements are filed. As the UDB continues to mature, it provides a history for future procurement, from concept to deployment, in consistent/compatible data elements.

SECTION IV

CONCEPT OF OPERATION

GENERAL

This section presents the manner in which the UDB/DGTB would be utilized during RDT&E of a new weapon system. An overview of the weapon system design process is presented in the context of how, when, and why the UDB/DGTB would be utilized by those involved in the acquisition process.

SINGLE POINT MANAGEMENT

As a new aircraft weapon system program progresses through the CDP, validation, and full-scale development phases, the Aeronautical Systems Division (ASD) is assigned single Air Force management responsibility for all aspects of the RDT&E program. During these program phases, the weapon system progresses through the CDP, PDP, and DDP, and essentially all development, fabrication, assembly and testing (Categories I and II) are completed. Throughout this period, however, many organizations exert strong influence on the destiny, design, schedule, and cost (LCC) of the weapon system. Figures 2, 3, and 4 show the UDB/DGTB system elements, basic input/output relationships, and system users as a function of the CDP, PDP, and DDP, respectively.

PRE-CONCEPTUAL PHASE

Initially the ASD SPO cadre prepares a Mission Element Need Statement (MENS). This is a coordinated effort with support from Air Force laboratories, AFLC, operational commands (OP CMD), and others. Prior to the program initiation decision (DSARC 0), ASD, with support from the AFALD, may utilize the UDB/DGTB central data processor to selectively analyze AFLC historical data (Figure 2) for comparison with top level planning data to identify mission requirements and manpower, support, and cost constraints.

UNIFIED DATA BASE (EVOLVING NEW WEAPON SYSTEM) AND
DATA GENERATING TECHNOLOGY DATA BASE – CONCEPTUAL OVERVIEW

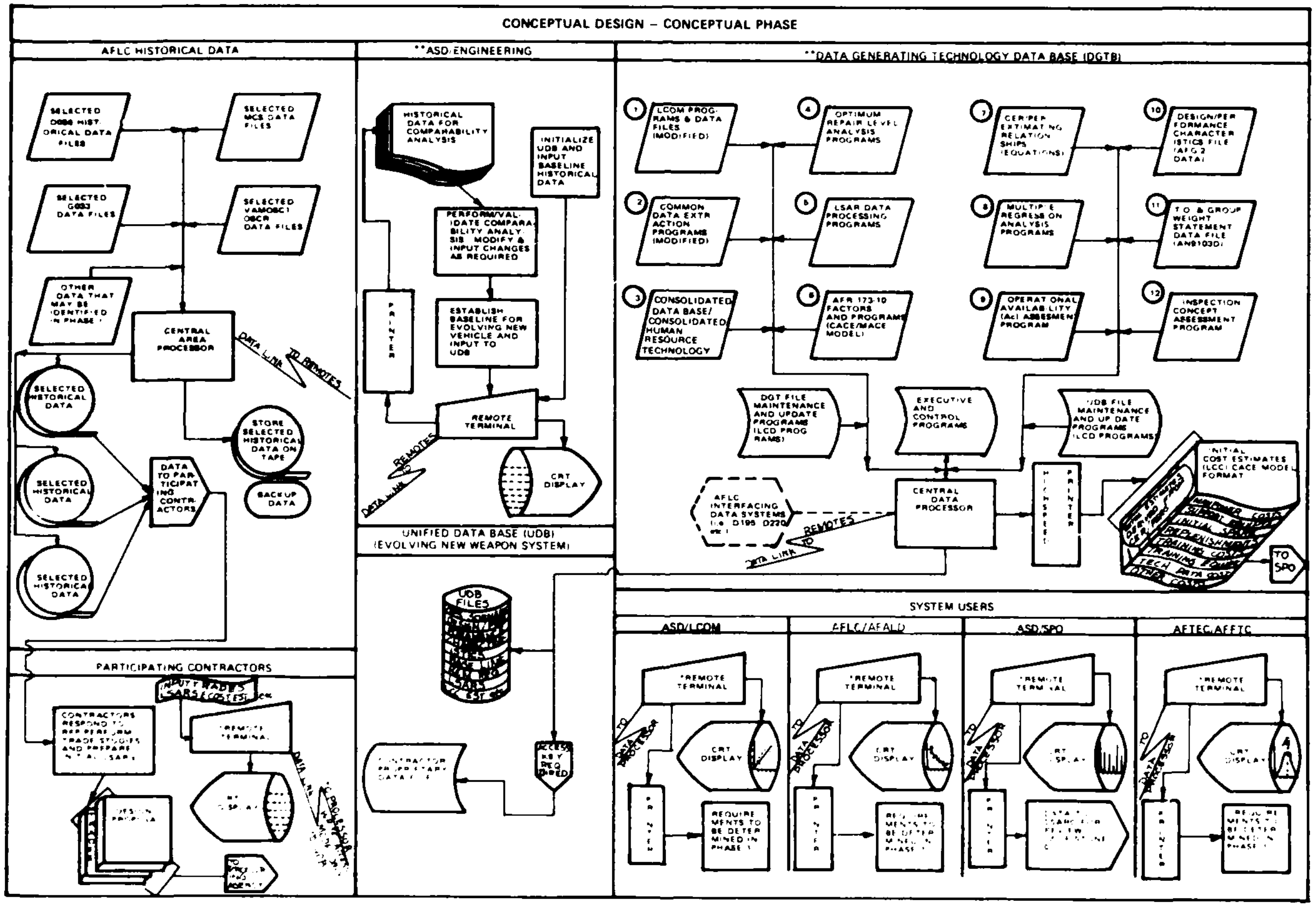

FIGURE 2 UDB CONCEPTUAL PHASE

EXPANDED DEFINITIONS FOR THE DGTB CONCEPTUAL OVERVIEW

1 & 2 LCOM PROGRAMS AND DATA FILES: INCOMPATABILITIES WITH THE CURRENT LCOM DATA ELEMENTS AND THE DATA ELEMENTS PRESCRIBED BY MIL-STD-1388 MUST BE RESOLVED. THE INTENT IS TO AUTOMATE THE EXTENDED FORM 11 DATA FOR GENERATING MAINTENANCE NETWORKS. ANY SUCH EFFORT SHOULD BE BASED ON MIL-STD-1388 DATA ELEMENTS.

*3 CONSOLIDATED DATA BASE/CONSOLIDATED HUMAN RESOURCES TECHNOLOGY (CDB/CHRT): THIS INCLUDES INSTRUCTIONAL SYSTEM DESIGN, JOB GUIDE DESIGN, HUMAN RESOURCES IN DESIGN TRADES, DESIGN OPTION DECISION TREES, AND SYSTEM OWNERSHIP COSTING. THE INCORPORATION OF THIS TECHNOLOGY IN THE DGTB WILL REQUIRE FURTHER DEVELOPMENT. TO THE EXTENT POSSIBLE THE CDB/CHRT RESULTS WILL BE INCORPORATED INTO THE UDB/DGTB.

*4 OPTIMUM REPAIR LEVEL ANALYSIS (ORLA): THERE IS NO QUESTION THAT THIS IS A NEEDED DGT AND SHOULD BE AVAILABLE FOR USE IN THE DGTB. DUE TO TIME AND RESOURCE CONSTRAINTS, HOWEVER, IT IS NOT ANTICIPATED THAT THIS CAPABILITY CAN BE INCORPORATED INTO THE PROTOTYPE DGTB.

5 LSAR DATA PROCESSING PROGRAMS: THE PROGRAMS CURRENTLY IN USE BY THE ARMY AND COVERED IN DETAIL IN AMCP 750-16 AND ASSOCIATED USERS GUIDES, WILL BE INVESTIGATED FOR APPLICABILITY TO MEET THE AIR FORCE REQUIREMENTS. THE ARMY SYSTEM WAS DESIGNED AROUND MIL-STD-1388. ANY REVISIONS TO THE CURRENT MIL-STD-1388 WILL REQUIRE PROGRAM CHANGES.

6 AFR 173-10 FACTORS AND PROGRAMS: AFR 173-10 COST ESTIMATING FACTORS WILL BE NEEDED IN ORDER TO PROVIDE AND GENERATE CONSISTENT COMPARABLE COST ESTIMATES. ONLY THE CURRENT FACTORS WILL BE INCLUDED, ALONG WITH THE DE-ESCALATION FACTOR TABLE TO ADJUST TO BASE YEAR $ VALUE.

7 CER/PER ESTIMATING RELATIONSHIPS: THIS REFERS TO COST OR PARAMETRIC ESTIMATING RELATIONSHIPS THAT CAN BE IDENTIFIED THROUGH LITERATURE RESEARCH ALREADY DEVELOPED AND VALIDATED. THE EQUATIONS AND PARAMETER DEFINITIONS WOULD BE PROVIDED IN THE OUTPUT--USERS WOULD PROVIDE THE PARAMETER VALUES TO DERIVE THEIR ESTIMATE. AREAS THAT APPEAR MOST FREQUENTLY ARE R&M WHEN ONLY THE TOP LEVEL DESIGN/PERFORMANCE CHARACTERISTICS ARE KNOWN.

*INDICATES THOSE TECHNOLOGIES NOT ANTICIPATED TO BE INCLUDED IN THE PROTOTYPE DGTB

FIGURE 2. *continued*

EXPANDED DEFINITIONS FOR THE DGTB CONCEPTUAL OVERVIEW

*8 MULTIPLE REGRESSION ANALYSIS PROGRAMS: THIS RELATES TO THE SELECTION OF THE MOST DESIRABLE PROGRAM THAT CAN BE IDENTIFIED IN PHASE I FOR INCLUSION IN THE DGTB. THIS WOULD PROVIDE THE USERS WITH THE CAPABILITY TO GENERATE THEIR OWN PERs/CERs GIVEN THE PARAMETERS TO BE USED FOR BOTH THE DEPENDENT AND INDEPENDENT PARAMETER VALUES. THIS PROGRAM WOULD BE USED IN CONJUNCTION WITH BLOCKS 10 AND 11.

*9 OPERATIONAL AVAILABILITY (A_o) ASSESSMENT PROGRAM: THE PROGRAM DEVELOPS MAINTENANCE CONCURRENCY FACTORS FOR ESTIMATING DOWN TIME WHEN THE NUMBER OF TASKS TO BE CORRECTED ARE KNOWN.

*10 DESIGN/PERFORMANCE CHARACTERISTICS FILE: THIS DATA FILE WOULD BE USED IN CONJUNCTION WITH BLOCK 8. AFG-2 IS ONE SOURCE THAT HAS BEEN USED FOR THIS TYPE OF DATA. THE DESIGN PARAMETERS ARE NOT PROVIDED IN THE AFG-2 IN ALL CASES. SYSTEM SPECIFICATIONS MAY ALSO BE NEEDED AS A SOURCE FOR DESIGN PARAMETERS WHICH MAY PROVE TO BE MORE APPROPRIATE FOR DESIGN TRADES.

*11 TECHNICAL ORDERS AND GROUP WEIGHTS STATEMENTS (AN9103D): THE NUMBER OF COMPONENTS, NUMBER OF SYSTEMS, POWER (KVA), ETC., HAVE BEEN USED SUCCESSFULLY AS INDEPENDENT PARAMETERS FOR ESTIMATING SYSTEM LEVEL MMH/FH. THE APPLICABLE TECHNICAL ORDERS PROVIDE THE SOURCE FOR THESE PARAMETER VALUES. THE SAME IS TRUE FOR SYSTEM GROUP WEIGHT STATEMENTS. THE AN-9103D REPORTS PROVIDE A SOURCE FOR THESE VALUES.

*12 INSPECTION CONCEPT ASSESSMENT: THIS IS A MUCH NEEDED DGT. DATA NEEDED TO INCORPORATE THIS CAPABILITY INTO THE DGTB IS NOT CURRENTLY COLLECTED BY THE MDCS.

*INDICATES THOSE TECHNOLOGIES NOT ANTICIPATED TO BE INCLUDED IN THE PROTOTYPE DGTB.

FIGURE 2. *continued*

CONCEPTUAL PHASE

After DSARC O, ASD will explore alternative system approaches to satisfy the MENS and established constraints. An overview of the CDP is presented in Figure 2.

BASELINE UDB

At this point, the selection of the current operational system(s) to be used for establishing the historical baseline for the evolving new weapon system would be made. The required data would be retrieved from existing data systems and stored in the UDB. These data on current operational system(s), which most closely resemble the new evolving weapon system, will be used for comparability analyses and to initialize the UDB for the new weapon system.

In addition to the historical data for use in establishing the baseline, other pertinent information is also required to initially define the UDB. As currently envisioned, the following data files are examples of data that would establish the UDB in the early stages of the CDP of a new weapon system development program:

- Operational scenario (operational concept, number of aircraft, number of bases, utilization or sortie generation rate, for both peacetime and wartime operation, etc., unless classified).
- Design and performance characteristics (weight, speed, range, altitude, payload) goals or "design to" requirements.
- Maintenance and support concepts.
- System readiness goals.
- R&M (including built-in test equipment, if applicable) parameters critical to system readiness and support cost.
- Limited scheduling information (to be defined during prototype UDB/DGTB development).
- Maintenance and support cost data on current system(s) used to establish baseline and perform trade studies.

- Other requirements that may be identified in the prototype UDB/DGTB development effort.

HISTORICAL DATA SOURCES

The sources for retrieval of the historical data for use in establishing the historical baseline and for performing trade studies will be finalized during the early phase of the UDB/DGTB development effort. Specific sources to be considered will be as follows:

- MDCS.
- Base Level Maintenance Cost System.
- Visibility and Management of Support Costs (VAMOSC).
- Operational Support Cost Reports (OSCR).
- Supply data will be needed but source must be determined later.
- USAF Cost and Planning Factors (AFR 173-10).
- Others that may be identified in the UDB/DGTB development effort.

USE OF DGTB

Conceptually the DGTB would include some programs designed to support the LSA process by operating on the data stored in the UDB. Other programs in the DGTB would operate on data stored in the DGTB to generate input data to the UDB. Still other programs in the DGTB would retrieve and operate on data from existing data systems for use in the LSA process, and to interface with technologies such as LCOM. In any case, use of the DGTB would be to perform the following support functions, as examples:

- Utilize existing PERs and CERs.
- Develop new PERs and CERs.
- Accomplish design trade studies and analyses.
- Perform ORLA
- Establish initial estimates for LSAR data elements.
- Assess impacts for variable levels of utilization.
- Assess inspection requirements.

- Assess operational availability.
- Others that may be identified in the UDB/DGTB development effort.

Throughout the CDP, ASD/AFALD will use the UDB/DGTB to initialize the UDB and input baseline historical data for comparability analyses. The DGTB will provide top level PERs/CERs to support the initial LCC estimates. As the CDP progresses, the top level system specification is established, and the baseline for the evolving system is input to the UDB.

INDUSTRY USE OF UDB/DGTB

During the CDP, the ASD will solicit and obtain industry participation in the initial weapon system concept identification and definition. ASD/AFALD would utilize the UDB/DGTB system to establish system level requirements and goals relevant to HR&LS requirements. These requirements and goals will be stored in the UDB at this point.

The aerospace contractor begins to exert a strong influence on the destiny, design, schedule, and cost of a weapon system after contract award. Remote access to the UDB/DGTB enables the contractor to retrieve selected AFLC historical data, conduct comparability analyses, and develop the initial system specification and UDB baseline. As conceptual and parametric trade studies are conducted, the contractor will utilize the DGTB to support these efforts. For example, at this point, various system concepts, configurations, and parameters are investigated, and the initial weapon system data (operational scenario, support concept, weight, range, speed, payload, etc.) have been input to the UDB. Using this baseline, the contractor will utilize the DGTB to retrieve and process historical data to be used for the comparability analyses and establishment of the initial system data base which is stored in the UDB in the form of initial LSARs (system level). The DGTB is also used to operate on the historical data to generate new data such as CERs and PERs. The DGTB would also be used to provide LCC inputs to support program management decisions. It is emphasized that the contractors will have access to appropriate Government data to use as a basis for initial LSA (baseline operating scenario, support/

maintenance concept, system requirements and goals, maintenance and support cost data on current systems, etc). Areas where the UDB/DGTB is intended to provide useful support data include:

- Identification of ILS element requirements consistent/compatible with system constraints and goals.
- Identification of HR&LS cost drivers on current (similar) systems.
- Identification of critical HR&LS parameters, and analyses to support establishment of targets, goals, thresholds for the system.
- Identification of requirements for major support-related hardware, such as training simulators, automated test equipment, etc.

VALIDATION PHASE

By the time official approval (DSARC 1) to proceed into the validation phase is obtained, the conceptual design is essentially completed and a top level system specification (functional baseline) is available. Figure 3 shows the UDB/DGTB and user operation following DSARC 1. The UDB will contain all relevant HR&LS information that has evolved and expanded throughout the CDP.

UDB/DGTB USERS

SPO and Contractors

As the weapon system progresses through preliminary design, the UDB continues to expand commensurate with lower levels of system design definition. Parametric and design trade-off studies continue, and the SPO/AFALD and contractors continue to utilize the DGTB to support these efforts.

AFALD

As the SPO/AFALD increasingly implements LSA through contractors, the expanded LSAR data is input to the UDB. Government and contractors will utilize the DGTB to generate estimates of HR&LS requirements. Upon completion of the validation phase, the allocated system baseline is

UNIFIED DATA BASE (EVOLVING NEW WEAPON SYSTEM) AND
DATA GENERATING TECHNOLOGY DATA BASE – CONCEPTUAL OVERVIEW

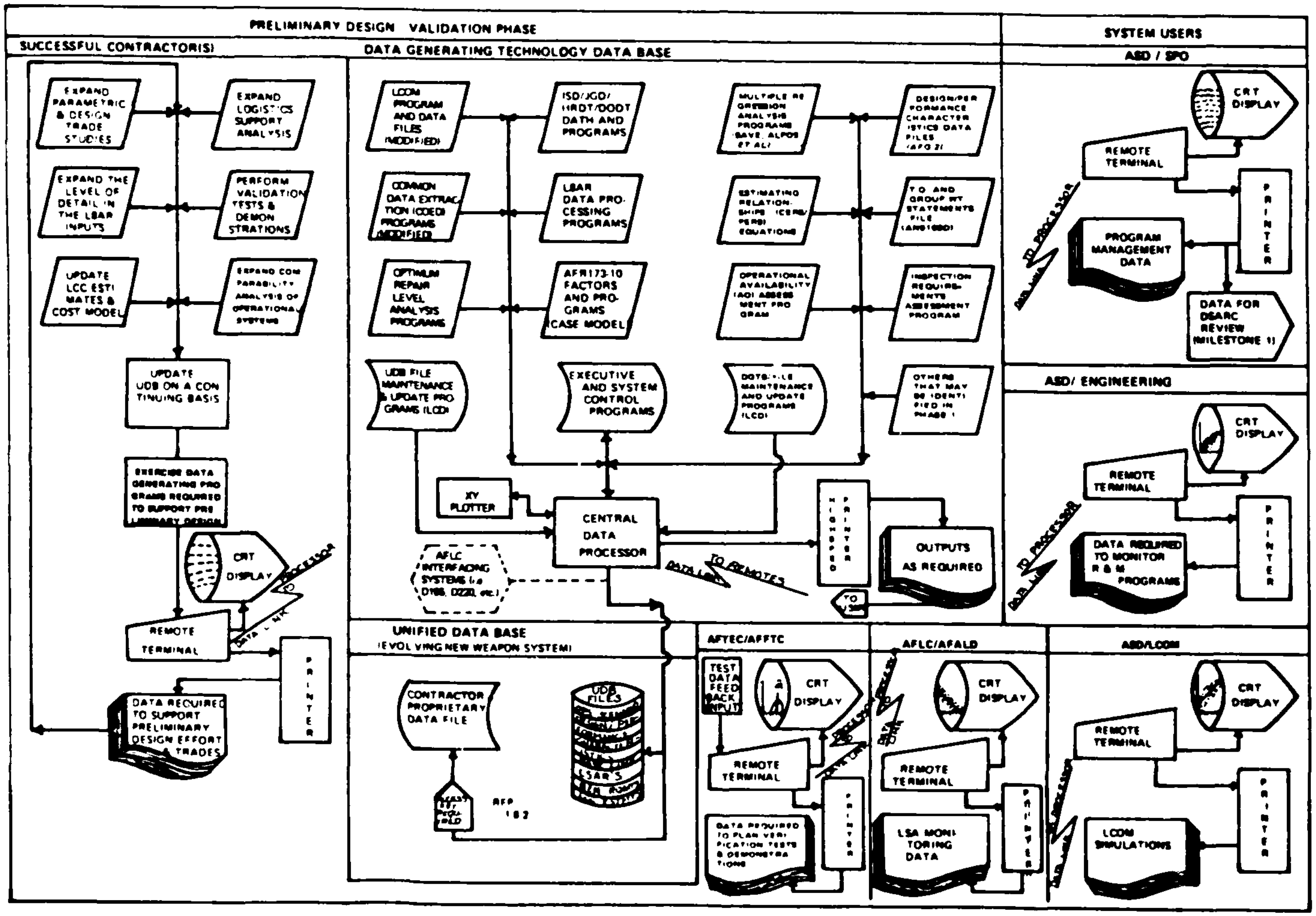

FIGURE 3 UDB VALIDATION PHASE

essentially defined and documented. Weapon system documentation will include the System Specification, the Air Vehicle Specification and Prime Item Development Specifications (Part I). At this point, the UDB will contain appropriate HR&LS related information at the subsystem levels. The DGTB will be used to operate on these data as desired/required to satisfy SPO, AFALD, and other user needs to support program management planning (including LCC estimates) for FSD.

ASD

ASD and AFALD will utilize the DGTB to operate on the UDB information in support of LCOM studies. The DGTB outputs will be consistent and compatible with LCOM.

UDB/DGTB INFORMATION

During the validation phase the UDB/DGTB is intended to provide information to support a DSARC II decision relative to the following areas:

- Conduct trade studies involving hardware, HR&LS concepts and impacts. Estimation of HR&LS requirements consistent with system level performance and support parameter goals and thresholds.
- Establishment of key HR&LS parameter goals, targets and/or requirements to influence future design. Sensitivity analyses of HR and LS requirements to changes in key system performance parameters.
- Identification of unique, rare and/or costly skills, training, and support/training equipment requirements.
- Establishment of a contractual baseline operational scenario and maintenance support concept.

FULL-SCALE DEVELOPMENT PHASE

After official approval (DSARC II) is obtained to proceed into FSD, the detailed design of the system is initiated. It is noted that considerable detailed design of selected systems may have been accomplished during the validation phase, particularly if competitive prototype demonstrations are involved. By the end of FSD, the detailed design, fabrication, assembly, and testing (Category I and II) or the entire air vehicle system will have been accomplished. Figure 4 shows the UDB/DGTB and users concept of operation during FSD. During this period, the SPO/AFALD will, primarily through contractors, accomplish detailed LSARs from which data are input to the UDB. These LSAR data are operated upon by the DGTB to generate refined HRD to support final decisions regarding training requirements, job guide (technical data) development, support equipment, ORLA, etc. The UDB is used to provide outputs to AFLC interfacing systems such as D-195, D-220, etc. In addition, the UDB is used to support detailed ILS planning, and to ensure traceability of HR&LS requirements from initial goals, targets, thresholds to the detailed allocated and specified characteristics in the system design, and to ensure comparability at detailed levels with contemporary systems.

PRODUCTION PHASE AND OPERATIONAL TEST AND EVALUATION (OT&E)

At the time approval for production is obtained (DSARC III), the UDB will contain information needed to support ASD, AFALD, Air Training Command (ATC), and OP CMD in the remaining development and overall acquisition of all logistics support elements; that is, facilities, support equipment, training programs, training equipment, manpower job guides (technical data), initial and replacement spaces, etc.

AFTEC USE OF UDB

After the AFTEC is tasked with the responsibility for OT&E of a weapon system, the UDB will provide consistent and compatible data for comparing weapon system estimates with demonstrated results.

UDB Trackability

The UDB data elements will ensure consistency and compatibility between RDT&E, OT&E, and O&S data systems. As a result, the UDB will provide a weapon system history that will enable direct comparison

UNIFIED DATA BASE (EVOLVING NEW WEAPON SYSTEM) AND
DATA GENERATING TECHNOLOGY DATA BASE – CONCEPTUAL OVERVIEW

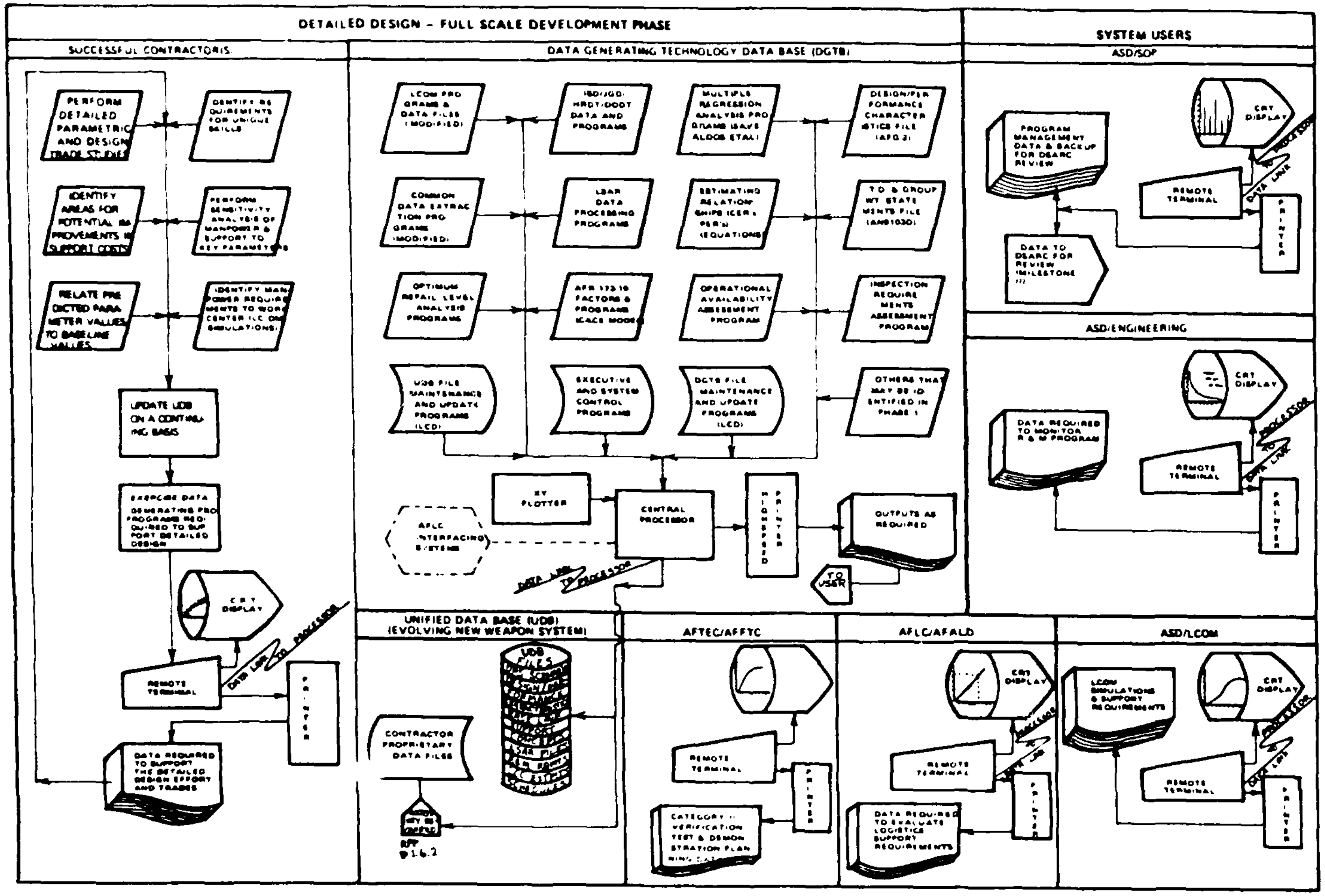

FIGURE 4 UDB–FULL–SCALE DEVELOPMENT PHASE

between initial system estimates and real-world results after deployment. This will be true for subsystems as well as for the overall system. The maintenance task analysis can be tracted from the original LSA, through the AFTEC OT&E, to the actual field experience after deployment.

Inactive UDB File

At some appropriate time in the weapon system acquisition process, primary Air Force responsibility is shifted from AFSC to AFLC. At that time, the UDB would be transferred to magnetic tape and become a part of the Air Force historical files. Subsequently the O&S records on the weapon system would be collected and processed through normal existing data systems for updating the historical files. The DGTB would retrieve, process, and otherwise operate on the newly deployed weapon system data as it normally does to satisfy the needs of its users (weapon system designers) when data are needed from this historical data source.

Reactivate for Modifications

The UDB for the newly deployed weapon system will remain in the Air Force historical data file throughout the life of the weapon system. If a major modification is required on an operational weapon system, the UDB for that weapon system (which is in the historical file) will be updated as applicable. The update will include any major changes in mission as well as other relevant data elements. When the modification is completed, the UDB will be again transferred to magnetic tape and stored in the historical UDB file.

HISTORICAL UDB FILE FOR FUTURE ACQUISITION PROGRAMS

When ASD is assigned responsibility for a new weapon system acquisition program, it will search the historical UDB file (by using the DGTB) to identify existing weapon systems and subsystems that are similar to the new weapon system. By utilizing the historical UDB, MDCS, MCS, and other data (via the DGTB), the predicted, allocated, and realized values for similar systems can be investigated. This should significantly improve the accuracy of predictive techniques used early in the design process to influence design of the new system. In addition, improved accuracy in prediction and planning for actual HR&LS requirements should result in a smooth transition to the O&S phase and improved cost-effectiveness of the new weapon system.

SECTION V

DEVELOPMENT APPROACH

GENERAL

This section describes the recommended approach for the development of a prototype UDB/DGTB. Since it is known that the Air Force is planning a three-phase program for the prototype UDB, the discussion of development activities presented herein is tailored to a three-phase prototype program as follows:

PHASE I - UDB/DGTB DEFINITION AND SYSTEM LEVEL DESIGN

PHASE II - UDB/DGTB DETAILED DESIGN AND DEVELOPMENT

PHASE III - UDB/DGTB TEST, DEMONSTRATION, AND TRAINING

IMPORTANT CONSIDERATIONS

Assuming that the concepts of the UDB and DGTB (Sections III and IV) are acceptable, there are many important factors to consider before the actual development of prototype is begun in Phase II. Moreover, answers to some key questions should be obtained before the program progresses beyond the midpoint of Phase I. This section discusses some alternative development approaches and raises some key issues that should be resolved as early as possible in Phase I.

INDEPENDENT DEVELOPMENT ALTERNATIVES

DGTB Development Only

The DGTB could be developed and implemented completely independent from the UDB. That is, a standard DGTB could be created to provide information to support trade studies/design decisions whether or not a UDB was ever developed. Without the UDB, however, it would be necessary to modify the data inputs, as required, to achieve compatibility with the standard DGTB programs. It would also be necessary to modify the associated data processing programs to support each weapon system acquisition. In addition, without a UDB, the single thread of HR&LS data (contained in the UDB for specific weapon systems) would not materialize. This would mean, of course, that the UDB experience data would not be available to improve the predictive programs in the DGTB. It is noted that the utilization of the single thread UDB to support the design process for future weapon systems acquisition is a major objective of the UDB and is perhaps the most important in the long term.

UDB Development Only

Conversely, the UDB could be developed completely independent of the DGTB. The single thread of HR&LS data could be developed for a specific weapon system to satisfy the first two major objectives of the UDB. That is, the UDB could be used to improve planning, avoid duplication, and provide an audit trail to realistically determine in OT&E how well the weapon system met its objectives. The problem is that without the DGTB for use in the early design stages, the UDB information would be severely limited and lack credibility until after the detailed LSARs have been accomplished late in the full-scale development phase. As a result, the UDB would be developed without the benefit of the DGTB to influence the design process.

As indicated previously, both the DGTB and the UDB are needed to support the weapon system acquisition process. The "single thread" concept of the UDB is the crucial element necessary to satisfy all three major objectives of the UDB. The DGTB is essential to ensure that HR&LS factors are considered early in the design process to influence system design decisions. The UDB "single thread" trackability of data from conceptual design through deployment will depend upon resolving the incompatibilities, providing sources of data to fill voids, elimination of redundancies, and duplication of effort that are identified by Thomas, et al. (1979a, 1979b) and in Section II of this report.

AIR FORCE POLICY

In establishing the UDB and DGTB, policy guidance and decisions will be required in several areas. Will the Air Force support and implement procedures (recommended in Report III, Thomas et al.,1979b)for revising the data now collected so as to achieve compatability with MIL-STD-1388 task analysis and AFM 66-1 action taken/how malfunctioned codes? These are far reaching policy matters and some may require

DOD approval, such as proposed changes to the "how malfunctioned" codes. Others are more easily achieved, such as the performing work center information in the LOG-MMO(AR)7142 reports, which are within the authority of the Air Force to change. The final approach to the development of the prototype UDB/DGTB will depend on the answers to the questions posed.

There are other questions that must be addressed. In the case of duplication/redundancy the possibility exists that the UDB could provide AFLC data that could eliminate the need for systems such as D-195, D-220, etc. Policy guidance would be needed to determine whether the prototype effort should be accomplished with the objective of developing a UDB to eliminate redundant systems.

Historically, data retrieval, extraction, processing and reformatting programs developed for specific type data, such as R&M data published in AFALDP 800-4, would require revision based upon the Clemson industry survey (Thomas et al., 1979a, 1979b). Many recommendations throughout the industry requested these data at more detailed levels (3 and 4 digit WUC). In addition, many recommendations were made to include crew size and elapsed time information in addition to the R&M parameters provided in AFALDP 800-4. Furthermore, if the recommendations made in the Clemson study (Thomas et al., 1979a, 1979b) for revising the MIL-STD-1388 task analysis definitions and AFM 66-1 action taken/how malfunctioned codes to achieve compatibility are accepted, there is a need for a steering group made up of ASD/EN, AFLC/AFALD, AFTEC and selected contractors to make recommendations for the required changes. The steering group would provide specific guidance to the contractor as to how the data elements are to be grouped to display the R&M data, such as that contained in AFALDP 800-4, and to conform to the terms and definitions in AFR 80-5.

HISTORICAL PERSPECTIVE

In the past years, the AFM 66-1 data were considered to be primarily a base level reporting system. The majority of the recommendations for changes to the coding came from the base operational level with little representation from AFSC/ASD. This was initially done through world-wide maintenance management conferences where working groups were given specific portions of AFM 66-1 and related 00-20 series technical orders to review and make recommendations for changes/revisions. Since that time, the use of AFM 66-1 MDCS data has been expanded to almost every conceivable level of Air Force maintenance and logistics activity. However, there has never, until the present, been a concerted effort on the part of AFSC/ASD and AFLC to try to achieve changes needed to support future acquisition programs. The formulation of a formal steering group to ensure that the UDB/DGTB development optimally satisfies these needs is crucial to the ultimate success of the program.

PHASE I

UDB/DGTB DEFINITION AND SYSTEM LEVEL DESIGN

Phase I of the prototype UDB/DGTB effort will develop a detailed definition of the UDB/DGTB to be developed and demonstrated in Phases II and III. The specific objectives of Phase I will be:

(a) Identify and define the specific data and DGT to be included in the prototype development of the DGTB.

(b) Identify and define the specific data elements to be included in the prototype development of a UDB.

(c) Identify the existing data systems that will be utilized by the UDB/DGTB and describe the interfaces, modifications required, and operational modes.

(d) Establish the manner, scope, and development approach for programming the DGTB and UDB for computer operation.

(e) Establish the initial procedures for operation of UDB/DGTB, including accessing, updating, and maintenance.

INITIAL (PARALLEL) ACTIVITIES--STEPS 1 & 2

The first step in the Phase I development effort will be to study all of the relevant literature to ensure that the Phase I effort builds upon previous research and insight obtained from them. The literature search should be limited to recent documentation that may be relevant to this effort but is not covered in the Clemson (Thomas et al., 1979a, 1979b) and other key studies. Major emphasis should be focused on critical review/validation of the suitability of data systems and DGT recommended as the baseline in this report. The search should also focus on areas where existing historical data and/or technologies are lacking/underdeveloped. The basic purpose of this portion of the study is to support objectives (b) and (c) listed previously.

The second step (closely related to parts of the first) will be to identify and validate the specific data needs of ASD/XR, ASD/EN, AFALD, AFTEC, and industry. The Clemson industry survey (Thomas et al., 1979a, 1979b) provides information and insight to data needed to support the design process. In addition, the Clemson study obtained information regarding the needs of ASD/XR. It is expected that the needs of ASD/EN will be closely aligned to the needs of industry. Rather than conduct a survey of ASD/EN, it is recommended that in Phase I the contractor be required to first validate and then present the results of the industry survey, including data needs identified, to key ASD/EN personnel to identify additional needs. After accomplishment of or careful review of the AFTEC data system, the AFTEC needs should be integrated with those of ASD/XR, ASD/EN, and industry. A presentation should then be given to AFTEC personnel to ensure that all AFTEC needs are identified. Following that effort a careful review of MIL-STD-1388, AFM 66-1, and other data systems should be conducted to identify AFALD needs. A meeting should be held with AFALD to ensure that all data needs are identified. It is recommended that these meetings with users be conducted separately as working sessions rather than combined as formal briefings.

IDENTIFY/DEFINE DATA ELEMENTS (STEP 3)

Based upon the results of steps 1 and 2, the third step will be to accomplish objectives (a), (b), and (c) listed previously. To the maximum extent practical, all of the data needs will be incorporated into a detailed definition of the UDB/DGTB in a consistent, compatible, and integrated manner. In addition, the relationships and interfaces with existing data systems will be identified and described. The approach to accomplish this should be to utilize the ARMY LSAR Automated Data Processing (ADP) system as the baseline file structure and file maintenance and up-date procedures, modified as necessary to satisfy the Air Force requirements. The Army programs already exist with appropriate documentation (record layouts, logic flow diagrams, etc., including user guides).

During Phase I, the additional data files needed to support an evolving new weapon system will be identified and defined (i.e., operational scenario, design/performance characteristics, support concepts, etc.). For each additional data file established, the required file maintenance and up-date programs will be described.

DGTB Definition

The outputs of the DGTB will be identified so as to satisfy user needs, establish the interface and compatibility with UDB data elements, accomplish the basic function of generating data, and accommodate user operational modes. In the following paragraphs, the desired data generating capabilities that would be most effective in satisfying user data needs in the conceptual and validation phases are discussed. Then, the data generating technology approach for the prototype UDB/DGTB is discussed. The prototype DGTB approach recognizes the fact that not all of the desired technologies can be incorporated, because of practical constraints (time, funding, etc.).

Desired Data Generating Technology - Conceptual Phase: Based on the Clemson study (Thomas et al., 1979a, 1979b) findings, Table 3 shows the generic data generating capabilities that are the most important to satisfy the conceptual phase user needs. These capabilities are listed in descending order of importance.

Multiple regression programs already exist so establishing that capability in the DGTB may be a minor task. Establishing the aircraft characteristics, group weight statements and TO data file would be necessary, however, to take advantage of the multiple regression capability. Establishing this file for inventory systems would be a major task, but would result in dramatic improvements in quantity, quality, and utilization of HRD to influence early system design decisions. If this DGTB "multiple regression/system characteristics file" capability (which would be compatible with the UDB) could be made available to all contractors, the amount of new HRD generated and used to influence early design would increase sharply. PERs and CERs could be developed by the Government and contractors for R, M (including skills, skill levels, crew size, etc.), ground support and test equipment, training programs and equipment, job guides (technical data), and ground support manpower costs. These estimates could be developed at the top system level and subsystem levels for use throughout the conceptual phase. There is also a need for a standard data normalization program. This ancillary program would be incorporated into the DGTB, and the input data for the regression program would be first operated upon by this program. Utilization adjustment is a good example of normalizing needs.

TABLE 3. DESIRED CONCEPTUAL PHASE DGT

- Multiple Regression Programs.
- Existing PER/CER (Equations and Parameter description files).
- Aircraft Characteristics, Weight Statements and TO Data File (AFG-2 & AN9103-D).
- Data Normalizing Programs (utilization falls in this category).
- A_o Assessment Program
- Life Cycle Cost Model/Program

Utilization adjustment programs and availability assessment technology has been developed (programs will be modified) and would be the next most important and useful technology for use in the conceptual phase. These DGTB capabilities would provide the mechanism to generate and utilize HR&LS impact estimates in a manner which is compatible with and supportive of the system design process. The LCC model capability in the UDB/DGTB would then be able to utilize the outputs of the above data generating capabilities, and should result in greatly improved LCC estimates to support program management and DSARC I decisions.

Desired DGT - Validation Phase: Table 4 shows the additional generic data generating capabilities that are most important to satisfy the validation phase user needs. All of the DGTB capabilities needed

TABLE 4. DESIRED VALIDATION PHASE DGT

- Logistics Composite Model (LCOM) Programs
  - EX - VAL
  - Common Data Extraction Programs (CDEP)
- ORLA Programs
- Army LSAR Programs
- Inspection Requirements Assessment Programs
- Other Human Resources Technologies

for the conceptual phase will continue to be needed and used in the validation phase.

The LCOM, EX-VAL, and CDEP programs may be very useful in the later stages of the conceptual phase and will be of great value in the validation phase. ORLA programs will be useful throughout this phase to support the design process and UDB development. The Army LSAR programs will be useful early in the validation phase, and may be useful during the conceptual phase. It may be necessary to accomplish major modifications to the Army programs in order to satisfy Air Force requirements. An inspection requirements assessment program would be useful, but a data base of required information does not exist. Modification to AFTO 349, recommended in Report III (Thomas et al., 1979a, 1979b), would be required to establish the data base. If the data base were created, the DGTB program to generate useful and usable HRD could be developed and implemented. The technology developed by AFHRL (Goclowski, 1978a, 1978b, 1978c) may be useful in this phase of an acquisition program.

Prototype DGT - The above discussion of desired DGT was based on an objective assessment of the actual needs and technologies/capabilities required to best satisfy those needs. The time and funding constraints of a prototype UDB/DGTB development program would not permit the desired DGTB capabilities to be fully incorporated. The prototype UDB/DGTB should, however, incorporate as many capabilities as possible. Table 5 shows the technologies/capabilities that should be considered for incorporation into the prototype UDB/DGTB in their order of importance recognizing time, funding and procedural constraints. (See Figure 2 for a more detailed discussion of candidate technologies.)

TABLE 5. PROTOTYPE DGT

- Army LSAR Programs
- LCOM Programs (EX-VAL & CDEP)
- CER/PER (Existing) Models and Programs
- ORLA Program
- A_o Assessment Program
- Multiple Regression Program
- Aircraft Characteristics & TO Group Weight Statements Files (AFG-2 & AN9103-D)
- Inspection Requirements Assessment Program

Summary of UDB/DGTB Definition

The UDB/DGTB system definition should specifically define programs, data elements, functions, interfaces, and operation of the system. UDB/DGTB system definition should include all data files and data generating technologies to be incorporated and modifications required. In addition, the extent of programming and compatibility modifications required to retrieve and process historical data from existing systems so as to be consistent with the UDB should be defined. Finally, it should include the UDB data elements and LSAR data processing programs, including modification and programming requirements.

Progress Review and Go-Ahead

At this point in the Phase I program, it is recommended that the

Air Force convene a steering group meeting to receive a contractor presentation on the integrated data needs of all users. This meeting should occur not later than halfway through the Phase I time period. It is envisioned that at this time the Phase I contractor will have essentially completed objectives (a), (b), and (c) of Phase I. In addition, the contractor should receive Air Force guidance regarding any unresolved policy issues and the acceptability of proceeding with the remaining objectives of Phase I based upon the defined UDB/DGTB and interfacing systems.

PERFORM INITIAL SYSTEM DESIGN

The fourth step will be to establish the initial design of the prototype UDB/DGTB system and the detailed development plan for Phase II. This effort will establish the manner, scope, and development approach for programming the DGTB and UDB for computer operation (Phase I, Objective (d)). The initial system design will involve development of the criteria for the retrieval, file maintenance, and update programs (load, add, change, delete, and save) for the UDB and approximately six of the DGTs listed in "DGTB definition." The specific DGTs to be incorporated will be agreed upon in the Air Force review (previous paragraph). The specific data elements and outputs of each DGT will require thorough analysis for compatibility with the data elements of the UDB (compatible with MIL-STD-1388). This effort will establish the manner, scope and development approach for programming the UDB and DGTB for computer operation.

ESTABLISH CONCEPT OF OPERATION

The fifth and final step in Phase I will be to accomplish objective (e). This effort will provide the concept and proposed procedures for operation of the UDB/DGTB including accessing, updating, and maintenance. Special emphasis will be focused upon proposed procedures to be developed and demonstrated in Phases II and III of the prototype program.

PHASE II

UDB/DGTB DEVELOPMENT

The actual development of the prototype UDB/DGTB will be accomplished in Phase II. System specifications will be developed to the level of detail necessary for programming to be accomplished. Programming will then be accomplished and program documentation developed (record formats, data element definition, etc.) as required to adequately document the programs. Users manuals/procedures will then be developed.

UDB PROGRAMMING SPECIFICATION

A detailed specification for the UDB will be prepared. This document will identify the data elements that the UDB will contain, space requirements for each, and the format of the elements in the data base. Specific space for growth of the base will be provided. The specification will delineate the location and format of the various sources of each data element. Any multiple spaces that are to be provided for the same parameters will be identified. The specification will delineate the required update capabilities. Specific options, methods, techniques for display of the data will be specified. Subroutines, desired for basic manipulation of the data will be specified. These routines include options such as sort and display certain parameters by sort sequence or part number sequence; simple rate X quantity summations for selected subsystems or parts, and selective displays three or four digit codes; from-to sequences of codes or part number, etc. These capabilities of the UDB are not to be confused with the more sophisticated programs associated with the DGTB. Provisions for the capture and permanent retention of data elements prior to each update will be specified. This is necessary to provide a complete audit trail as the weapon systems progress through the various development stages. This type of historical data retention is vital to the overall success of and effective utilization of the UDB/DGTB technology. This specification will also include the extent of program flexibility required to be compatible with the CDC 6600 computer system at ASD, as well as the

IBM 370 and larger IBM computer systems. The programming language used will be coordinated and approved by the Air Force.

DGTB PROGRAMMING SPECIFICATION

The DGTB is conceived of as an expandable series of computer programs that perform HR analyses and/or provide data related thereto. As such, it shall be comprised of a number of separate computer programs, and/or data products, most of which already exist in various forms. The DGTB specification will therefore primarily address the revisions and modifications required to unify these models/technologies so as to be compatible with the computer system, data sources, UDB data elements, etc. The specification will delineate input sources and formats for each technology, many of which will come from the UDB, and will specify and describe to what extent the outputs of each of these technologies will be stored in the UDB. The extraction of input data from the UDB and input of selected results to the UDB by those technologies will be specified. Interactive communication will be specified. Programs between the UDB and the DGTB for data transfer will be included in this specification.

The DGTB specification will include a provision for a protected storage location within the computer where data and/or programs may be sorted and retrieved for analysis purposes. This storage location will also provide for limited expansion of the DGTB to fit the unique or special needs of an individual user. The DGTB system definition would allow for future expansion in order to add/modify technologies.

PROGRAMMING

The detailed specification of the UDB and that of the DGTB will commence on a concurrent basis. Programming associated therewith will commence as various segment specifications are finalized. Programs will be written in Fortran (or some other suitable language) and will be first established to operate on the contractor's computer. The ability to convert these programs to the CDC 6600 and IBM 370 systems will be a firm constraint. Differences in tape densities, memory sizes, dimensions, statements, etc. will be specially delineated in the program documentation.

USERS HANDBOOK

The contractor will provide a users handbook that contains specific instructions for operating both the UDB and the DGTB. This handbook will completely delineate all capabilities of both bases and specifically how each capability can be accessed and utilized via remote consoles and/or batch output directly from the computer center. Step-by-step keyboard strokes will be included for use of each program. Example inputs and resulting outputs will be included. Limitations of both data and technology bases will be clearly stated. Simplified instructions for non-programmers pertaining to how to call up programs, how to call up data, how to execute programs, etc. will be clearly provided in the users handbook.

PROGRAM DOCUMENTATION

Detailed documentation of each UDB and DGTB program will be developed. This will include record formats, detailed data element identification and description, computer codes, and data file descriptions.

PHASE III

TEST AND DEMONSTRATION

The prototype UDB/DGTB will be developed so as to be compatible with other computer systems currently in use. Specifically, the system will be compatible with the CDC 6600 and IBM 370 equipment. Remote terminals will be established at Wright-Patterson AFB and at least one contractor facility. After the prototype UDB/DGTB is developed and all programs are operating, the system will be demonstrated using actual or representative data to load an initial UDB for a weapon system that is in the conceptual phase. Users will access the central data processor of the system and exercise LSAR and DGTB programs to generate data as is applicable and appropriate. It is recommended that, if possible, the same exercise be accomplished for a weapon system that is in the validation phase. It may be feasible and practical to use a recently developed system (F-15, F-16, etc.) to simulate an evolving weapon system program to demonstrate the UDB/DGTB. That way, multiple program phases could be "experimentally conducted" to test the utility and validity of the UDB/DGTB, with the advantage of having actual data for comparison. The difficulties of designing a realistic and objective experiment would be proportional to the degree to which the early program activities (trades, specifications, etc.) were documented and to the availability of such data.

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ABBREVIATIONS

ADP	Automated Data Processing
AFALD	Air Force Acquisition and Logistics Division
AFHRL	Air Force Human Resources Laboratory
AFLC	Air Force Logistics Command
AFSC	Air Force Systems Command
AFTEC	Air Force Test and Evaluation Center
ASD	Aeronautical Systems Division
A_o	Operational Availability
ATC	Air Training Company
BITE	Built-in Test Equipment
CACE	Cost Analysis Cost Estimating Model
CSB	Consolidated Data Base
CDEP	Common Data Extraction Program
CDP	Conceptual Design Phase
CER	Cost Estimating Relationship
CER/PER	Cost and Parametric Estimating Relationships
CHRT	Consolidated Human Resources Technology
DDP	Detailed Design Phase
DE	Design Engineer
DGT	Data Generating Technology
DGTB	Data Generating Technology Base
DOD	Department of Defense
DODT	Design Option Decision Tree
DSARC	Defense Systems Acquisition Review Council
DTC	Design-to-cost
EN	Directorate of Engineering, ASD
FSD	Full-Scale Development
GSE	Ground Support Equipment
HR	Human Resources
HRD	Human Resources Data
HRDT	Human Resources in Design Trade-offs
HRF	Human Resources Factor
HR&LS	Human Resources and Logistics Support
HRR	Human Resources Requirements
ILS	Reliability, Maintainability & Integrated Logistics Support Engineer
ISD	Instructional System Development
JGD	Job Guide Development
LCC	Life Cycle Cost
LCOM	Logistics Composite Model
LRU	Line Replaceable Unit
LS	Logistics Support
LSA	Logistics Support Analysis
LSAR	Logistics Support Analysis Record
LSC	Logistics Support Cost
M	Maintainability
MCS	Maintenance Cost System
MDCS	Maintenance Data Collection System
MENS	Mission Element Needs Statement
MP COST	Ground Support Manpower Cost
MMH/FH	Maintenance Manhours/Flight Hour

MMM	Maintenance Manpower Model
OP CMD	Operational Command
O&S	Operation and Support
ORLA	Optimum Repair Level Analysis
OSCR	Operational Support Cost Report
OT&E	Operational Test and Evaluation
PDP	Preliminary Design Phase
PE	Chief/Project Engineer
PER	Parametric Estimating Relationship
R	Reliability
R&M	Reliability and Maintainability
RDT&E	Research, Development, Test and Evaluation
RFP	Request for Proposal
SEDS	Systems Effectiveness Data System
SOW	Statement of Work
SPO	System Program Office
SRU	Shop Replaceable Unit
TA	Technology Assessment
TO	Technical Order
UDB	Unified Data Base
VAMOSC	Visibility and Management of Support Costs
WBS	Work Breakdown Structure
WUC	Work Unit Code
XR	Advanced Planning Directorate, ASD

AD-A093 282 CLEMSON UNIV SC F/G 15/3
HUMAN RESOURCES DATA IN WEAPON SYSTEM DESIGN: AN INITIAL PLAN F--ETC(U)
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DEPARTMENT OF THE AIR FORCE
AIR FORCE HUMAN RESOURCES LABORATORY (AFSC)
BROOKS AIR FORCE BASE, TEXAS 78235

Errata

16 JAN 1981

REPLY TO ATTN OF: TSR

SUBJECT: Removal of Export Control Statement

TO: Defense Technical Information Center
Attn: DTIC/DDA (Mrs Crumbacker)
Cameron Station
Alexandria VA 22314

1. Please remove the Export Control Statement which erroneously appears on the Notice Page of the reports listed [redacted]. This statement is intended for application to Statement B reports only.

2. Please direct any questions to AFHRL/TSR, AUTOVON 240-3877.

FOR THE COMMANDER

Wendell L Anderson

WENDELL L. ANDERSON, Lt Col, USAF
Chief, Technical Services Division

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List of Reports

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